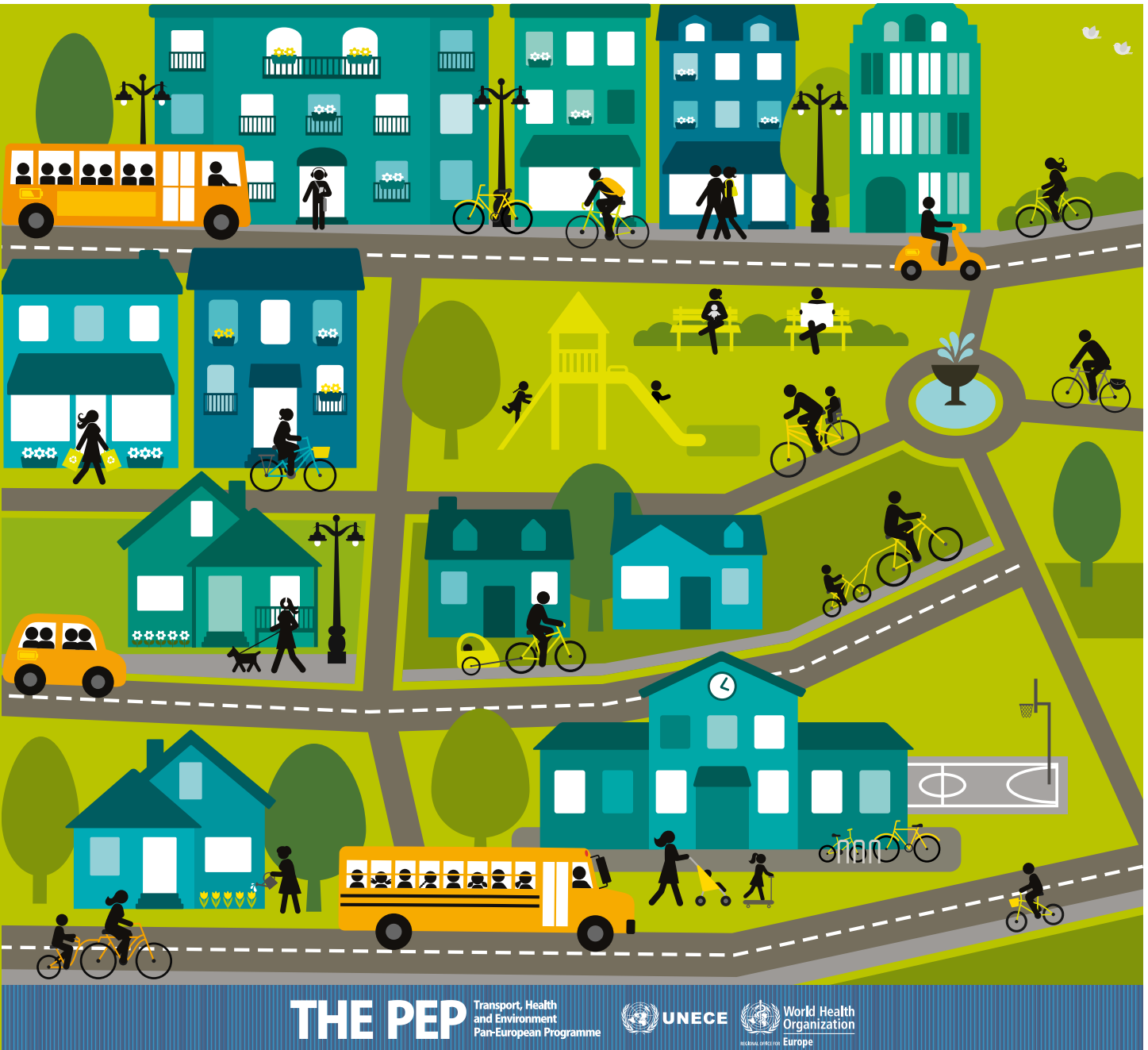


# Jobs in green and healthy transport

## Making the green shift





SOCIAL JUSTICE  
DECENT WORK



**UNECE**

## **Jobs in green and healthy transport: Making the green shift**

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<sup>[1]</sup> The participants in the Partnership are Yasmina Baaba, Nicholas Bonvoisin, Christian Brand, Jean Chateau, Xavier Delache, Claus Doll, Silvano Domergue, Julien Fernandez, Virginia Fusé, Dionisio González, Marina Lagune, Rémi Pochez, Francesca Racioppi, Isabelle Richaud, Matthias Rinderknecht, Werner Rothengatter, Nino Sharashidze, Luisa Sievers, Acacia Smith, Elisabeth Suci, Nathalie Tessier, Philip Turner and Kirsten Wiebe.

<sup>[2]</sup> See Appendix IV for the list of Steering Committee members.

## Executive summary

This study, commissioned by the Steering Committee of the Transport, Health and Environment Pan-European Programme (THE PEP) through its Partnership on Jobs in Green and Healthy Transport, examines the economy-wide employment implications of an accelerated shift towards greener land transport in the region of the Economic Commission for Europe (ECE).

Land transport is an important sector in terms of job creation and economic development. It employs over 60 million workers around the world, representing more than 2 per cent of global employment. Total employment is even higher if one counts the indirect jobs that depend on value chains associated with the transport sector.

At the same time, because of the resources it consumes and the pollution it causes, transport also contributes to environmental degradation and to health problems. If global and local environmental objectives are to be achieved while promoting the transport sector as a source of decent work, it is essential that the pursuit of environmental sustainability should be at the heart of policy development.

A macroeconomic multiregional input–output model has been used in this study to analyse the employment implications of four “green transport” scenarios in the ECE region. Projections up to 2030 obtained using a business-as-usual scenario were compared with projections from the modelling of each of those four scenarios, which envisage an accelerated expansion of public transport and the electrification of private passenger and freight transport. The specific scenarios modelled were:

- For public transport:
  - PT.1: Doubling investment in public transport;
  - PT.2: Free public transport.
- For electrification:
  - E.3: Introduction of a voluntary or mandatory target of 50 per cent of all vehicles manufactured to be fully electric;
  - E.4: Ban on internal combustion engines for light commercial vehicles.

Our projections indicate that there would be diverse job impacts across the ECE region, as each country’s transport sector is linked through various supply chains to other economic sectors within the same country and to sectors in other countries across the world.

The analysis carried out for this report suggests that employment opportunities would indeed be opened up by the promotion of green and healthy transport in the ECE region. Stimulating the use of public transport by doubling investment (scenario PT.1) and making public transport free (scenario PT.2) could create at least 2.5 million additional jobs in the transport sector worldwide. This increases to at least 5 million jobs if the wider impact on other sectors of the economy is considered. More than half of these new jobs would be in the ECE region alone.

The introduction of a voluntary or mandatory target of 50 per cent of all vehicles manufactured to be fully electric (scenario E.3) would result in a net total of almost 10 million jobs being added to world employment across all sectors, of which 2.9 million would be in the ECE region alone. If we take just the transport sector, it is estimated that employment will increase by 0.7 million jobs, of which about 0.6 million jobs would be in the ECE region. A ban on internal combustion engines for light commercial vehicles (scenario E.4) would lead to 0.4 million new jobs in transport and to as many as 8.5 million new jobs if the impact on other sectors is also taken into account. The ECE region is likely, however, to see a contraction in certain sectors, since the net job creation under these two scenarios masks considerable reallocation, with jobs moving away from the manufacture of motor vehicles and the petroleum industry towards the service sector.

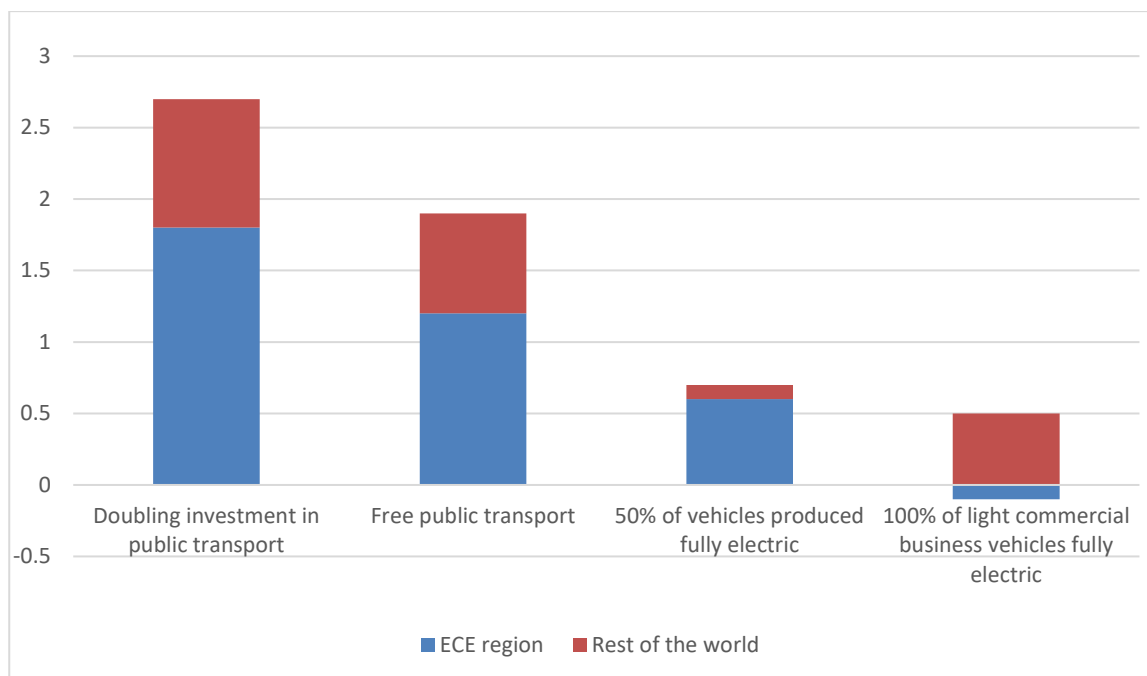
Net job creation under all four scenarios would be driven mainly by a structural shift from fossil fuel consumption and production to increased use of public transport services and the electrification of transport.

Reduced fuel consumption has particularly strong positive effects on employment in oil-importing countries. Government spending on the fuel industry, which has a very low employment content, can be redirected to other sectors of the economy with a greater impact on employment, such as public transport.

Under the two electrification scenarios considered in this report, industries engaged in the manufacture of electrical machinery and appliances and in battery production stand to gain, whereas a reduction in employment is expected to occur across the fuel value chain and in the traditional automotive industry. Countries with a strong manufacturing base for cars with internal combustion engines that fail to seize opportunities to switch to the production of electric vehicles will face a reallocation of jobs to those countries that are pioneering the shift towards electric transport.

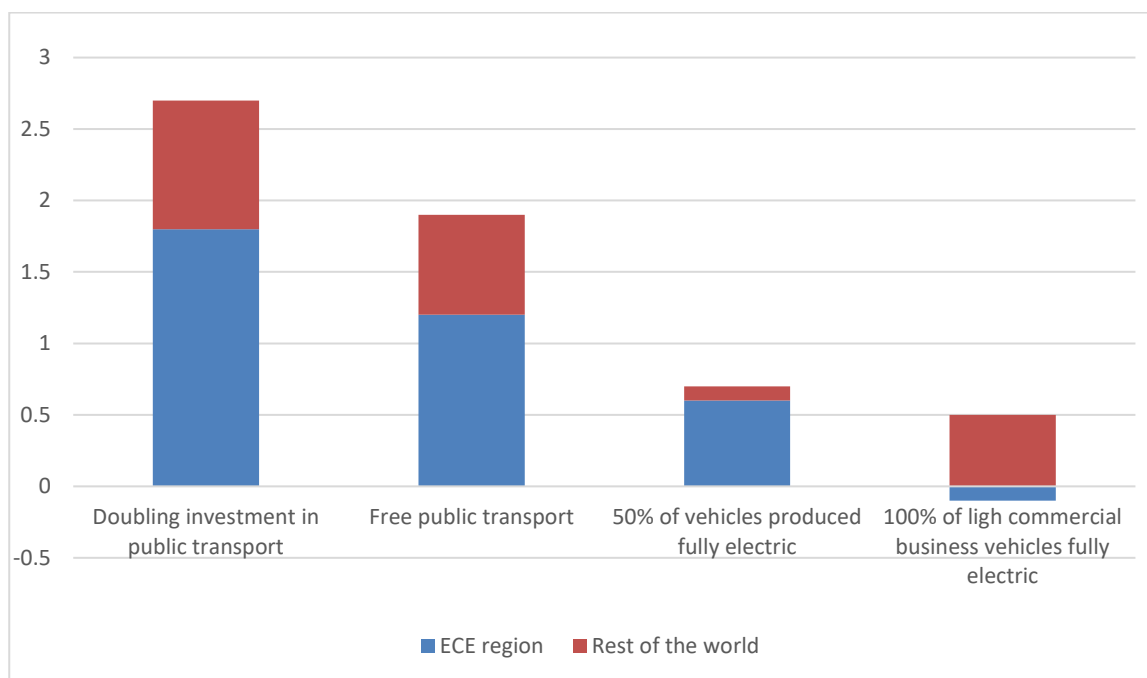
The two figures below illustrate the net job creation resulting, respectively, in the transport sector and in the economy as a whole from the adoption of policies to promote green and healthy transport.

**Figure E.1. Net job creation (in millions) in the transport sector under each of the scenarios modelled in the study**





**Figure E.2. Net job creation (in millions) in the whole economy under each of the scenarios modelled in the study**



To capitalize on the employment opportunities opened up by a greening of the transport sector and ensure a just transition for workers, businesses, regions and countries that may face restructuring, a comprehensive set of policies should be implemented at the same time. These should include skills development policies, social protection policies, active labour market policies, and policies to promote both social dialogue (especially if green transport is to be financed through “green taxes”) and fundamental rights at work. It is also important to have in place an industrial policy designed to foster the industries that would grow under a green transport scenario and that may currently still be undeveloped in the ECE region.

Promoting sustainability through the expansion of public transport and the electrification of private passenger and freight transport is just one of the areas in which future developments will affect employment throughout the economy. Other important areas whose impact on job creation deserves further study are automation, shared mobility, cycling, hyperloop transport systems, delivery drones, and “buy local” or “short circuit” economies.

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## 1. Introduction

The study whose findings are presented in this report was conducted by the International Labour Organization (ILO) in cooperation with the Economic Commission for Europe (ECE), the Regional Office for Europe of the World Health Organization (WHO), the United Nations Environment Programme (UNEP) and other organizations participating in the Partnership on Jobs in Green and Healthy Transport under the Transport, Health and Environment Pan-European Programme. It builds on the work done under that programme to evaluate the job creation potential of green and healthy transport (UNEP, 2017; WHO, 2014). The study was also designed to support activities initiated by the ILO, following a request of its Governing Body, to estimate the labour market effects of the transition to environmental sustainability.<sup>1</sup> Expanding the scope of previous studies, it shows how the transition towards green and healthy transport will alter the structure of sectors and jobs not just within ECE member States<sup>2</sup> but also in other parts of the world, since greening the transport sector has implications for national, regional and global value chains and for employment in many different industries.<sup>3</sup>

Transport is a key sector in the global economy (UNEP, 2017). Specifically, land transport accounts for more than 60 million direct jobs around the world, representing over 2 per cent of global employment.<sup>4</sup> By enabling the mobility and connectivity of people and goods, transport sustains the activity of many other sectors across the economy, creating jobs, adding economic value and promoting social inclusion. As such, the transport sector is a key player in advancing the 2030 Agenda for Sustainable Development.

However, the transport sector also has various adverse impacts on the environment and human health. Thus, it is a major contributor to the emission of greenhouse gases (GHGs) responsible for climate change and also contributes to air pollution, acid rain, eutrophication, crop and forest damage, natural resource depletion, habitat fragmentation and waste generation.<sup>5</sup> The transport sector also poses significant risks to human health through road injury, air and noise pollution, and traffic congestion.<sup>6</sup>

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<sup>1</sup> This report complements the ILO's assessment of the employment impact of a transition to sustainability in the energy, agriculture and resource and waste management sectors (ILO, 2018), and ties in with the policy framework outlined in the ILO *Guidelines for a just transition towards environmentally sustainable economies and societies for all* (2015).

<sup>2</sup> The model used in this study has the world economy represented by 44 countries and five rest-of-the-world regions. The countries are Australia, Austria, Belgium, Brazil, Bulgaria, Canada, China, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, India, Indonesia, Ireland, Italy, Japan, Republic of Korea, Latvia, Lithuania, Luxembourg, Malta, Mexico, Netherlands, Norway, Poland, Portugal, Romania, Russian Federation, Slovakia, Slovenia, South Africa, Spain, Sweden, Switzerland, Taiwan (China), Turkey, United Kingdom and United States. The regions are "Rest of Africa", "Rest of Asia", "Rest of Eastern Europe", "Rest of Latin America" and "Rest of Middle East". This study draws on the 2014 data in EXIOBASE version 3, which are available from: [www.exiobase.eu](http://www.exiobase.eu).

<sup>3</sup> As elaborated below, this has to do with the global supply chains in which transport is enmeshed. For example, the production of electric vehicles requires a higher share of imported materials from outside the ECE region, such as batteries from China. This in turn has implications for labour demand in the ECE region.

<sup>4</sup> In the United States, for example, transport accounted for 9 per cent of gross domestic product (GDP) in 2015 and employed about 13 million people, or 9 per cent of the labour force, in 2016 (US Department of Transportation, 2018). In the European Union, almost 12 million people, or more than 5 per cent of the total workforce, worked in the transport and storage services sectors in 2016 (European Commission, 2018). On average, European households spent 13 per cent of their total expenditure on transport-related items in that year (ibid.). Transport is also a key player in international trade, accounting for a significant proportion of service exports in several countries in the ECE region. In 2016, transport services contributed to more than 40 per cent of service exports in Belarus, Denmark, Kazakhstan, Latvia, Lithuania, Norway, Tajikistan and Ukraine (World Bank, 2018).

<sup>5</sup> Direct GHG emissions from the transport sector account for 14 per cent of global emissions (IPCC, 2014). The sector's reliance on fossil fuels means that transport – especially road transport because of the increasing use of private cars – remains one of the main contributors to GHG emissions (ITF, 2017). Across ECE countries, transport's share of national GHG emissions ranges from under 10 per cent in Kazakhstan to more than 50 per cent in Sweden and Luxembourg (World Bank, 2018).

<sup>6</sup> Road injury was ranked as one of the top ten global causes of death in 2016 (WHO, 2016). In 2015 alone, road accidents killed more than 0.1 million people and injured more than 4.7 million in the ECE region (UNECE, 2016). Traffic noise can cause

The big environmental footprint that transport currently generates means that structural transformation of the sector can play a major role in promoting an environmentally sustainable, green economy. Indeed, reducing GHG emissions and air pollution, increasing transport safety, and improving health outcomes by encouraging active mobility are all priority areas for ECE member States. Promoting green and healthy transport is an essential part of efforts to achieve the Sustainable Development Goals (WHO, 2018). Acknowledging the fundamental links between transport, health and the environment, the governments of member States of the ECE and the WHO Regional Office for Europe established the Transport, Health and Environment Pan-European Programme (THE PEP) in 2002. The programme's main objectives are to integrate environmental and health considerations into transport policies while simultaneously fostering the creation of employment (WHO and ECE, 2009).<sup>7</sup>

The promotion of green and healthy transport will have a direct impact on jobs in the transport sector and in other sectors of the economy. Since such a transition alters the demand for certain modes of transport and this, in turn, influences demand for related goods and services, green and healthy transport will necessarily involve the creation of jobs in certain sectors and their destruction in others. It is necessary to consider both the direct and indirect effects on employment across countries and regions in order to help policy-makers to take well-informed decisions about investing in green transport and to design policies that support businesses and protect all workers during the transition.

The first publication by THE PEP on green and healthy jobs appeared in 2011, the same year that the Partnership on Jobs in Green and Healthy Transport was launched. This was followed by a study in 2016 looking specifically at green and healthy jobs associated with cycling. Overseen by the ECE and the Steering Committee of THE PEP, the present study evaluates the impacts on jobs in the period up to 2030 under two broad policy scenarios:

- (a) the expansion of public transport; and
- (b) the electrification of private passenger and freight transport.

These two scenarios are compared with a business-as-usual scenario developed by the International Energy Agency (IEA), which explores several energy and climate scenarios in its *Energy Technology Perspectives* report (IEA, 2017). This baseline scenario is largely a continuation of current trends (i.e. limited climate and energy action) and we assume that in 2030 there will be 6.24 billion people employed in all sectors across the world. The projections from the business-as-usual scenario are country- and sector-specific; they include the transport sector and take into account each country's projected energy demand per sector up to 2030. We have compared each of the public transport and electrification scenarios for the ECE region with the business-as-usual scenario to estimate the net employment difference across countries and sectors.

The results presented here have been obtained by employing a global model based on data from EXIOBASE, a multiregional input–output table. The main advantage of adopting such a modelling approach is that it makes it possible to study not only the evolution of employment in the transport sector under the various scenarios, but also to gain insights into how developments in the transport sector would affect the rest of the economy and the labour market. Furthermore, the effects can be analysed across countries and regions as well, which makes it possible to identify the sectors and regions in which jobs are most likely to be created and destroyed.<sup>8</sup> While there is a distinction between temporary and permanent jobs and between high- and low-skilled jobs in terms of how they contribute to people's well-being and the economy as a whole, this

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cardiovascular diseases, cognitive impairment, sleep disturbance, annoyance and tinnitus, adversely affecting productivity and quality of life. It is estimated that at least one million healthy life years are lost annually owing to traffic-related noise in Western Europe (WHO, 2011). Moreover, the use of motorized transport discourages active forms of mobility such as walking and cycling.

<sup>7</sup> One of the four priority goals of THE PEP is "to contribute to sustainable economic development and stimulate job creation through investment in environment- and health-friendly transport" (WHO and ECE, 2009).

<sup>8</sup> A detailed description of EXIOBASE can be found in Stadler et al. (2018). Further details of the modelling approach and methodology used in the present study are given in Appendix I and in ILO (2018).

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aspect is beyond the scope of this report. Further research would be necessary to obtain a more granular picture of the evolution of employment under the various scenarios.

Promoting sustainability through the expansion of public transport and the electrification of private passenger and freight transport is just one of the areas in which future developments in the transport sector will affect employment throughout the economy. Other important areas are automation, shared mobility, cycling, hyperloop transport systems, delivery drones, and “buy local” or “short circuit” economies. Though potentially relevant from the perspective of creating jobs in green and healthy transport, they, too, fall outside the scope of this study.

There are several ways in which the sustainability of the various modes of freight and passenger transport (road, rail, waterway and air) can be enhanced, including increased energy efficiency, the use of alternative clean and renewable fuels, modal shifts and electrification (especially when a large proportion of electricity is generated from renewables).

Many strategies are available for enhancing the fuel efficiency of new and existing road freight transport vehicles and reducing their emissions. These include switching to alternative fuels (to replace diesel), engine upgrades, improved aerodynamics and drag reduction, electrification, the development of lightweight materials for heavy- and light-duty trucks, and improved logistics management using information and communication technologies. However, despite the sound business case, these strategies have still not been widely adopted (Roeth et al., 2013; Aditjandra et al., 2016). In private passenger transport, efforts have been made to increase fuel efficiency and encourage modal shifts – e.g. by reducing the use of private cars in favour of public transport, cycling and walking in some cities (UNEP, 2017) – but there is still ample room for improvement. Currently, most passenger transport still takes place in fossil fuel-powered cars (European Commission, 2018).<sup>9</sup>

Previous studies conducted under THE PEP have shown that certain initiatives designed to support the transition to green and healthy transport, such as the promotion of cycling, will lead to net job gains (UNEP, 2017; WHO, 2014). We build on that earlier work here by assessing whether the promotion of public transport and the electrification of private transport in the ECE region can create employment opportunities and help achieve Sustainable Development Goal 8 (on decent work and economic growth) in the region and across the world.

It is important to stress that our analysis focuses on job creation, job reallocation and potential job destruction. As already noted, the extent to which the job creation projected under the various scenarios contributes to decent work falls outside the report’s scope. Nevertheless, decent work should be a key priority in the transition to green and healthy transport as part of broader efforts to promote social development and sustainability.

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<sup>9</sup> The present report focuses on land (road and rail) passenger and freight transport, which accounts for most employment in the transport sector. This does not mean that there is no scope for making other modes of freight transport more sustainable. For inland waterway freight transport, some ways of improving fuel efficiency are switching from oil to natural gas, retrofitting, installing equipment for efficient loading and unloading of cargo, and using larger, more energy-efficient cargo vessels. Energy savings and efficiency improvements can also be achieved in the transfer of goods between ports and terminals via different transport modes. With regard to maritime shipping, the high volume of black carbon emissions from the combustion of low-quality fuel could be reduced by switching from residual to distillate fuels or from distillate fuels to lower-sulphur fuels and other alternative fuels such as natural gas and biofuels, and installing exhaust gas cleaning systems on ships and diesel particulate filters (Comer et al., 2017). Maritime shipping can also be made more sustainable by improving the quality of the infrastructure and regional port facilities (Global Green Freight, 2018a). Sustainability in the aviation sector can be promoted through new aircraft designs, composite lightweight materials, improved engines, retrofitting engines and replacing winglets, and the use of alternative jet fuels. The fuel consumption and emission levels of the aviation sector can be further reduced through improvements in operations, such as avoiding delays and ensuring that aircraft operate at optimal elevations and use the most direct flight paths (Global Green Freight, 2018b).

## 2. The employment effects of expanding public transport in the region of the Economic Commission for Europe

Taking note of the proven environmental and health benefits of public transport (WHO, 2018), we open this chapter with a discussion of how investment in that sector can also affect employment. After reviewing the experiences of ECE countries and cities that have experienced a significant expansion in public transport in recent years, we consider two specific public transport scenarios. These are both compared with the business-as-usual scenario using a global model built from EXIOBASE, a multiregional input–output table.

Employment projections have been obtained for two different scenarios that would lead to increased use of public transport:

- Scenario PT.1: Doubling investment in public transport;
- Scenario PT.2: Free public transport.

### A. How the expansion of public transport affects employment

Increased use of public transport is expected to be accompanied by a reduction in the use of private motorized vehicles. The expansion of public transport increases employment in that sector and in related industries, such as the manufacture of public transport vehicles. On the other hand, it reduces employment in sectors related to private car use (e.g. the retail sale of fuel and the production, sale and maintenance of motor vehicles).<sup>10</sup>

Recent policies, such as the establishment of limited traffic zones in several cities in the ECE region, have discouraged car use in favour of public transport and active mobility (i.e. cycling and walking), though there is still scope for further expansion of public transport in Europe and elsewhere in the world.<sup>11</sup> The growth rate of car use (measured in passenger-kilometres) has declined in several countries in the ECE region (ECE, 2018). In Europe in 2014, there were almost 50 billion journeys on local buses, trams and underground rail, the highest recorded figure since 2000 (UITP, 2016). The modal share of private car use is expected to decrease in developed countries as a result of stringent policies, investment in infrastructure, and behavioural change (ITF, 2017). These three components are expected to offset increased demand for private car use resulting from population and income growth (ibid.). However, in a few cities, the rise of ride-hailing companies has changed the public transit landscape. In some cases, they have replaced public transport, while in others they complement the public transport system, highlighting the complex role of technology and policies in shaping the future of transport (Hall, Palsson and Price, 2018).

Globally, annual capital expenditure on transport is between US\$1.4 trillion and US\$2.1 trillion, with public investment contributing to between US\$569 billion and US\$905 billion. Around three-quarters of investment in public transport infrastructure takes place in high-income countries (Lefevre, Leipziger and Raifman, 2014). Because of the projected growth in demand, such investment is expected to increase by more than 50 per cent by 2030 (Dulac, 2013).

<sup>10</sup> Previous studies conducted under THE PEP provide concept and case studies highlighting the importance of public transport as a source of employment. For example, in WHO (2014) it is estimated that the share of (direct and indirect) jobs associated with the rail, light rail, bus, coach and cycling industries in the United Kingdom represents 38 per cent of all transport jobs in the country. However, it is not clear to what extent the expansion of public transport may lead to job destruction in other sectors, for example, owing to reduced demand for private transport.

<sup>11</sup> In our analysis we do not consider the health effects of such policies. The health benefits of an increased modal share of public transport are well documented for cities in Europe and the United States (Grabow et al., 2012; Holm, Glümer and Diderichsen, 2012; Rojas-Rueda et al., 2013; Woodcock, Givoni and Morgan, 2013). For example, Rojas-Rueda et al. (2013) find that replacing 40 per cent of short and long car trips with bicycle rides and public transport would significantly reduce the prevalence of a variety of diseases among travellers and the general population, particularly cardiovascular diseases and type 2 diabetes. Labour productivity tends to increase with lower levels of illness-related absenteeism.

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The International Transport Forum has projected future transport demand by mode for all regions of the world up to 2050 under three scenarios: “baseline”, “robust governance”, and “integrated land use and transport planning” (ITF, 2017). The robust governance scenario assumes the adoption of pricing and regulatory policies by local governments to slow down private car ownership and use. The integrated land use and transport planning scenario assumes joint land use and sustainable urban transport policies – such as promoting a greater supply of public transport, extensive deployment of mass transit, and restrictions on urban sprawl – in addition to the local government policies under the robust governance scenario. It is estimated that public transport’s share of total transport demand in Europe will increase from 19 per cent in 2015 to, respectively, 25 per cent, 50 per cent and 53 per cent in 2050 under the three scenarios (ibid.).

Changes to the public transport system will naturally affect employment in the sector (direct effects). Public transport is a major employer in itself. Specifically, urban public transport represents around 20 per cent of the output of the transport sector, and some 13 million people worldwide are employed by public transport services (UITP, 2013a). Direct investments in multimodal and public transport create a net employment gain compared with investments in private car-based transport (Gouldson et al., 2018).

Although a transition from private cars to public transport would lead to job losses in industries such as car manufacturing and petroleum refinery and distribution, it would promote employment in rail infrastructure construction and in the manufacture of public transport vehicles (indirect effects). The maintenance and operation of public transport systems are both major sources of employment. Indeed, public transport companies are among the biggest employers in the ECE region. In 2017, for example, 310,000 employees worked for the Deutsche Bahn (DB) Group, 740,000 for Russian Railways,<sup>12</sup> 27,000 for London Underground and 61,000 for the RATP Group in Paris. These companies, in turn, have long value chains relying on indirect employment in supply industries. Ernst and Sarabia (2015), for example, have calculated that for every US\$1 million invested in the construction sector, 8.5 jobs are created in Belgium, 39.8 in Turkey and 114.9 in the Russian Federation. Although some of these jobs can be short-term in nature, some temporary construction jobs are likely to become permanent as maintenance work is required on the newly built infrastructure. These estimates are for the construction sector as a whole rather than specifically for public transport infrastructure, however they motivate the approach taken in this report and the employment generating potential of public transport expansion (Cats, Susilo and Reimal, 2017).

In addition, the expansion of public transport, if accompanied by a modal shift from the use of private cars to public transport, reduces households’ spending on fuel. The consequent increase in disposable income means that households may spend part of their savings on other, non-transport-related goods, thereby helping to create more jobs (induced effect). Despite the reduced spending on fuel, there is net job creation because the fuel industry is based on oil extraction and refinery, which are highly capital-intensive sectors with little employment involved. Using input–output tables, Chmelynski (2008), for example, estimates that every US\$1 million spent by households on petrol and other private vehicle-related expenses generates about 13 jobs, while the same amount of expenditure could generate about 17 and 31 jobs if spent, respectively, on public transport and a typical set of household goods.

The total employment effect of expanding public transport in a given country depends on the linkages of that sector with other sectors in the economy, the extent to which those linkages create jobs, and the extent to which the inputs for public transport (e.g. fuel and energy) are obtained from within the national economy. Accordingly, the expansion of public transport in ECE member States can have a variety of direct and indirect implications for employment within and outside the region. This is one of the key reasons for using a global model built from a multiregional input–output table in the present study: with such a model one can analyse

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<sup>12</sup> The figures for the DB Group and Russian Railways include a significant share of staff employed in freight transport; the figure for the DB Group also includes employment in road freight.



the above-mentioned linkages and thus obtain estimates of the impact of each of the scenarios on employment levels across the whole economy.

There are other indirect employment effects stemming from an increase in the use of public transport. Thus, accessible, well-connected and inclusive public transport systems have been shown to improve employment accessibility and labour supply significantly (Sanchez, 1999; Johnson, Ercolani and Mackie, 2017; Matas, Raymond and Roig, 2010). Using cross-sectional census data in the United Kingdom, Johnson, Ercolani and Mackie (2017) found that areas with shorter travel times on public transport were associated with higher employment levels. In Barcelona and Madrid, women are more likely to be unemployed than men as a result of there not being enough jobs that can be accessed by public transport, which implies a further widening of gender inequalities (Matas, Raymond and Roig, 2010). These indirect impacts on employment (also known as “forward linkages”) are, however, not analysed here because they would require further modelling.

In general, the expansion of public transport affects employment both through the creation of jobs associated with the public transport sector and with the development of supporting infrastructure (direct effects) and through the creation of jobs associated with the provision of inputs for the public transport sector (indirect effects). Furthermore, given that urban public transport is cheaper than private transport, expansion of the former can lead to increased household consumption of other goods and services (induced effects). In parallel, the demand for private vehicles, fuel and related services is reduced.

When preparing the present study, a number of possible public transport scenarios were initially discussed by the ECE and the ILO. As a result of these discussions, which were later joined by the Partnership on Jobs in Green and Healthy Transport and by the Steering Committee of THE PEP, the following scenarios were singled out for consideration:

- Public Transport 1 (PT.1): Doubling investment in public transport;
- Public Transport 2 (PT.2): Free public transport;
- Public Transport 3 (PT.3): Doubling of public transport services;
- Public Transport 4 (PT.4): Ban on internal combustion engines for passenger transport within cities.

The ILO modelling team subsequently analysed the viability of each of these scenarios. It turned out that PT.3 would give the same results as PT.1 and so that scenario was dropped. Moreover, it was decided that PT.4 would be considered only in the context of the electrification of private transport (see the sections on scenario E.4 in Chapter 3).

Modelling of the two public transport scenarios selected for this study (PT.1 and PT.2) indicates that the expansion of public transport would have mixed effects on employment. As shown in the following sections, the expansion of public transport creates jobs in that sector and other sectors of the economy, but it can destroy jobs elsewhere. Significantly, many of the new jobs created will not necessarily be in the same sector or country. This highlights the need for complementary policies to meet the increased demand for jobs in the relevant sectors and countries, and to protect and support those workers who may end up losing their jobs. (Appendix I provides the methodological details that underlie the estimation.)

## **B. Scenario PT.1: Doubling investment in public transport**

After consultations with the Partnership on Jobs in Green and Healthy Transport and the Steering Committee of THE PEP, we chose increased investment in public transport as the first scenario to be modelled. This choice was also informed by earlier studies of the transport economy. Dulac (2013), for example, estimated that investment in public transport would increase by more than 50 per cent towards 2030. More recently, the International Transport Forum has estimated that public transport’s share in overall transport demand

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in both Europe and North America would more than double under its “robust governance” scenario (ITF, 2017).

The PT.1 scenario assumes a doubling of investment in public transport, which entails increased spending on two main areas of the transport sector: the building of public transport infrastructure and the production of rolling stock. In the first step of the scenario, each country’s investment in fixed capital stock (including rail infrastructure) is increased. Investment in rolling stock (including locomotives, carriages, buses and tramways) takes depreciation into account and is capped at the total value of the rolling stock required to achieve the same modal split between public and private transport as in the most advanced ECE countries.<sup>13</sup> In the second step, the operation and maintenance of the additional public transport capacity are modelled; in doing so, the increased public transport services on offer and their energy requirements are taken into account.

The scenario assumes that investment in public transport infrastructure is financed through a reallocation of funds from road to rail. The additional rolling stock is paid for through higher fuel prices (i.e. by raising the taxes paid at the pump) and to a lesser extent through higher vehicle prices (i.e. by raising the purchase tax on new vehicles), reducing the overall demand for fuel and moderately reducing sales of private vehicles. This in turn reduces employment along the value chain associated with the use of private cars (i.e. in such sectors as oil production and refinery, the retail sale of fuel, repair and maintenance, and, less markedly, the manufacture of vehicles).

In order to account for uncertainties and to provide a range of low and high estimates, the parameters used in the PT.1 scenario were modified by reducing or increasing total investment in the relevant industries of the transport sector (i.e. bus manufacturing, bus services, train manufacturing, train services and fuels) by 10 per cent.

The PT.1 scenario was then compared with a business-as-usual scenario developed by the IEA, which is mainly a continuation of existing patterns of sectoral economic growth and extrapolates to 2030 the currently limited action on climate and energy (IEA, 2017). The business-as-usual projections are country- and sector-specific, include the transport sector, and take into account each country’s projected energy demand by sector up to 2030.

### **C. Projections of employment under the PT.1 scenario**

Under the PT.1 scenario, the increased investment in public transport creates a demand for employment in the construction sector to build the additional infrastructure (mostly temporary and lower-skilled jobs) and in the value chain associated with the production of rolling stock (mostly permanent and higher-skilled jobs). This ultimately leads to a greater availability of transport and promotes employment in the sector itself (permanent and higher-skilled jobs). If accompanied by suitable policy measures, it may also encourage a modal shift away from cars towards greater use of public transport.

If investment in public transport were to be doubled between 2016 and 2030, the projected aggregate employment effects across the ECE region would be positive. The scenario assumes, however, that there is no net increase in spending on public infrastructure, but, rather, that spending is redirected within the infrastructure sector – more specifically, that investment in motorways and road infrastructure (excluding maintenance) is channelled towards public transport. This means that total employment in the infrastructure

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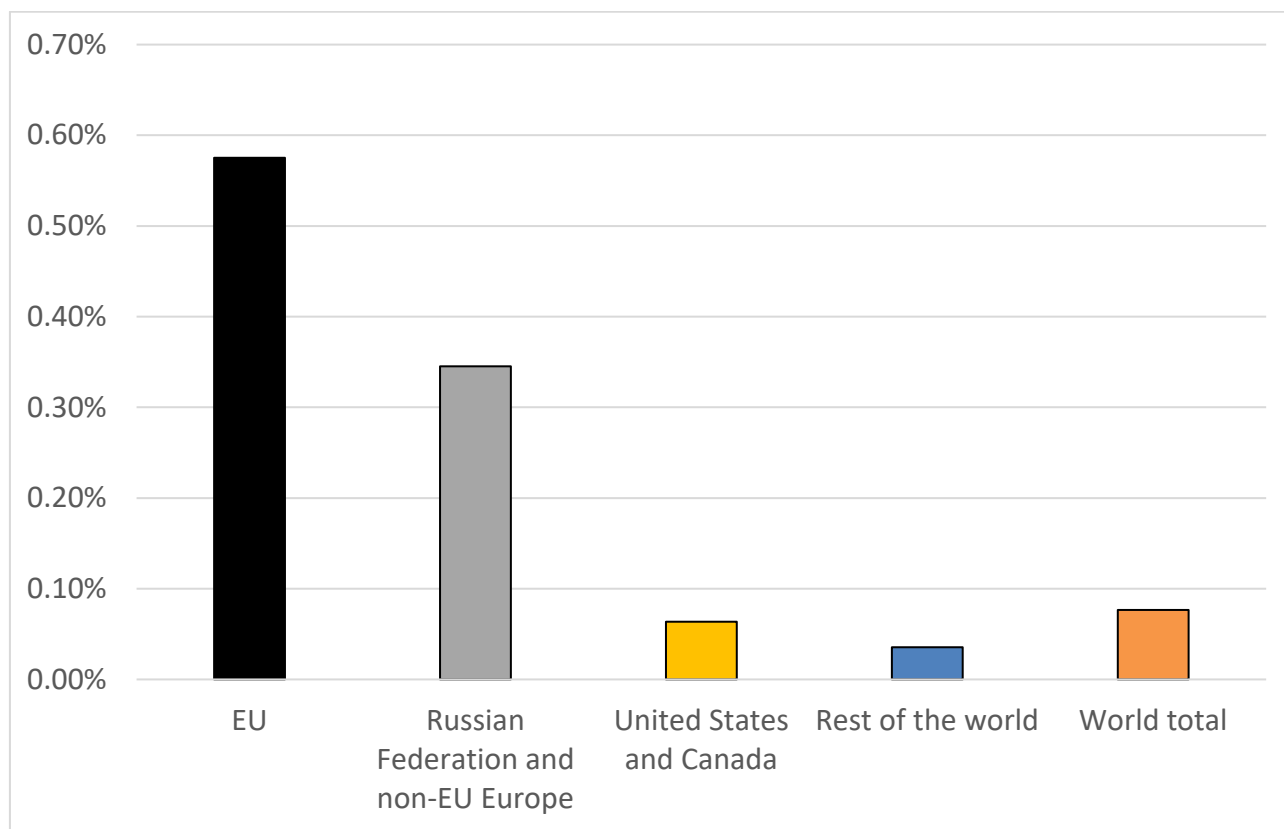
<sup>13</sup> Switzerland is the ECE country with the highest modal share of railways, while Turkey is the ECE country with the highest modal share of bus transport. For all other ECE countries, when modelling the PT.1 scenario, the doubling of investment was capped once the respective modal shares of Switzerland and Turkey had been reached.



and construction sectors and in the associated value chains are the same as if investment within the infrastructure sector has not shifted.

Increased investment in public transport means greater employment in the manufacture of rolling stock (i.e. buses and trains) and in the associated value chains. Because such investment has only a minimal substitution effect on car purchases and manufacturing (Beaudoin and Lin Lawell, 2018), additional production along the rolling stock value chain (e.g. the manufacture of vehicles and transport equipment) will have a net positive effect on employment. Figure 2.1 below illustrates the region-specific employment effects associated with doubling investment in public transport in the ECE region. The vertical axis shows the relative difference in employment levels (expressed as a percentage) between the PT.1 scenario and the business-as-usual scenario. For example, the doubling of investment in public transport in the ECE region by 2030 is projected to increase global employment by 0.08 per cent.

**Figure 2.1. Relative difference in employment levels between PT.1 scenario (investment in public transport doubled) and business-as-usual scenario, 2030 (%)**



Source: ILO estimates based on EXIOBASE version 3.

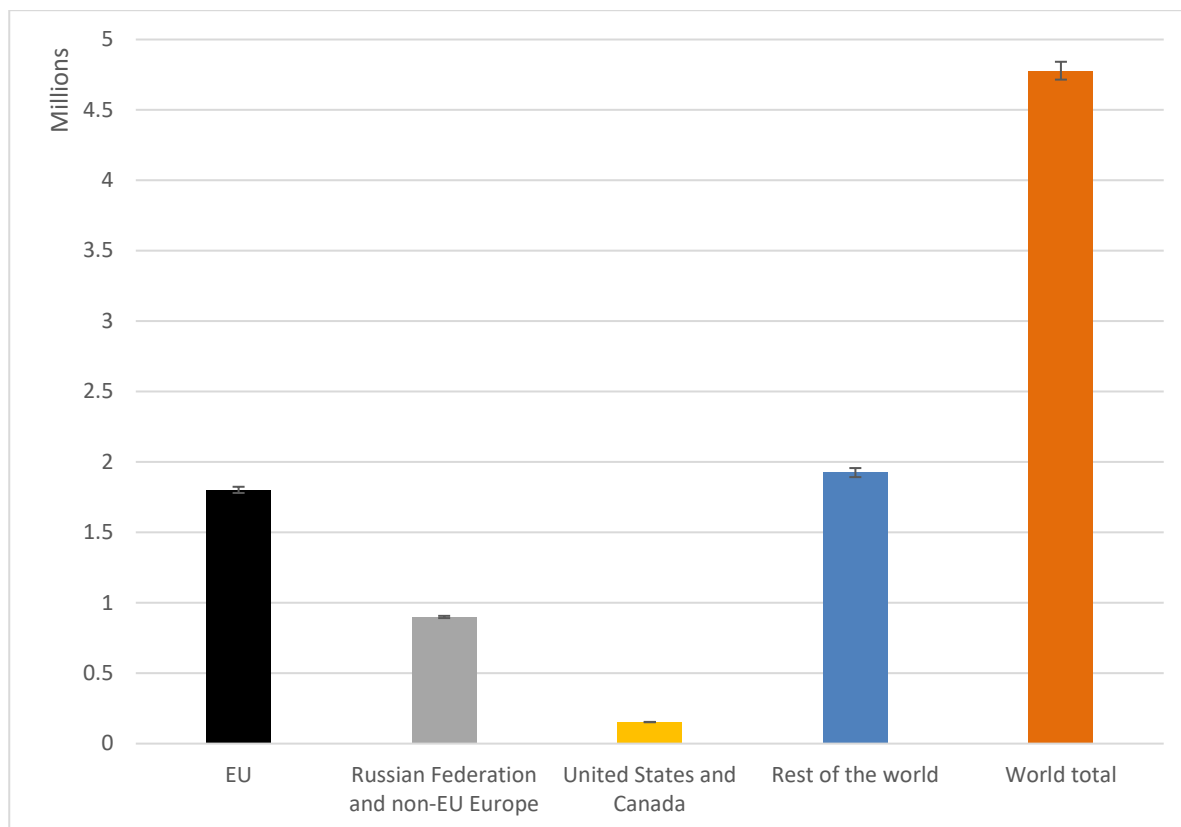
Figure 2.2 shows the absolute difference in employment levels in terms of the number of jobs. As can be seen, the increase in global employment by 0.08 per cent under the PT.1 scenario translates into around 4.8 million jobs created across all sectors by 2030. At the global level, this is a small change, but different regions are projected to experience varying levels of net job creation. In the European Union (EU) region, for example, employment under this scenario is expected to be 0.58 per cent higher (equivalent to a net creation of 1.8 million jobs) than under the business-as-usual scenario. In the Russian Federation and non-EU Europe, employment is projected to be 0.35 per cent higher, translating into a net creation of 0.9 million jobs. In the United States and Canada, the employment effect is minor, less than 0.1 per cent.<sup>14</sup> In all regions, the new jobs created are most likely to be permanent jobs in the operation of public transport services and in the

<sup>14</sup> These effects are generally small, particularly if they are spread over a period of time. As noted by Montt, Wiebe et al. (2018), the average employment growth per year across the world is 1.25 per cent. between 2005-2017.

manufacture of rolling stock, requiring a medium skill level (e.g. technicians, train and bus drivers, engineers and related fields of expertise).

The error bars in figure 2.2 show the employment effects of a 10 per cent variation in the level of investment envisaged by the PT.1 scenario. For example, an additional 10 per cent of spending on public transport in the ECE region would add a further 22,000 jobs in the EU region. Across the world, if the increase of public transport investment in the ECE region were 10 per cent lower than assumed under the scenario, 63,000 fewer jobs would be created. As one would expect, the greatest variation would be observed in the transport sector itself and in the industries engaged in the manufacture of rolling stock.<sup>15</sup>

**Figure 2.2. Absolute difference in employment levels between PT.1 scenario (investment in public transport doubled) and business-as-usual scenario, 2030 (million jobs)**



Source: ILO estimates based on EXIOBASE version 3. Whiskers represent low and high estimates.

Figure 2.3 shows the difference in employment levels between the PT.1 scenario and the business-as-usual scenario for each related sector and for the public transport sector itself. Not surprisingly, job creation is led by the public transport sector and the manufacture of rolling stock, notably in the EU. Employment in these sectors in the Russian Federation and non-EU Europe, and in the United States and Canada, is also projected to increase, but to a lesser extent than in the EU.

In the EU, employment in railway and bus services is projected to increase by over 25 and 8 per cent, respectively, or by around 267,000 and 570,000 jobs. The employment effect of a doubling of investment in public transport is also positive in the Russian Federation and non-EU Europe, with a net creation of 80,000 jobs in railway services and 430,000 jobs in bus transport. In the United States and Canada, by contrast, the

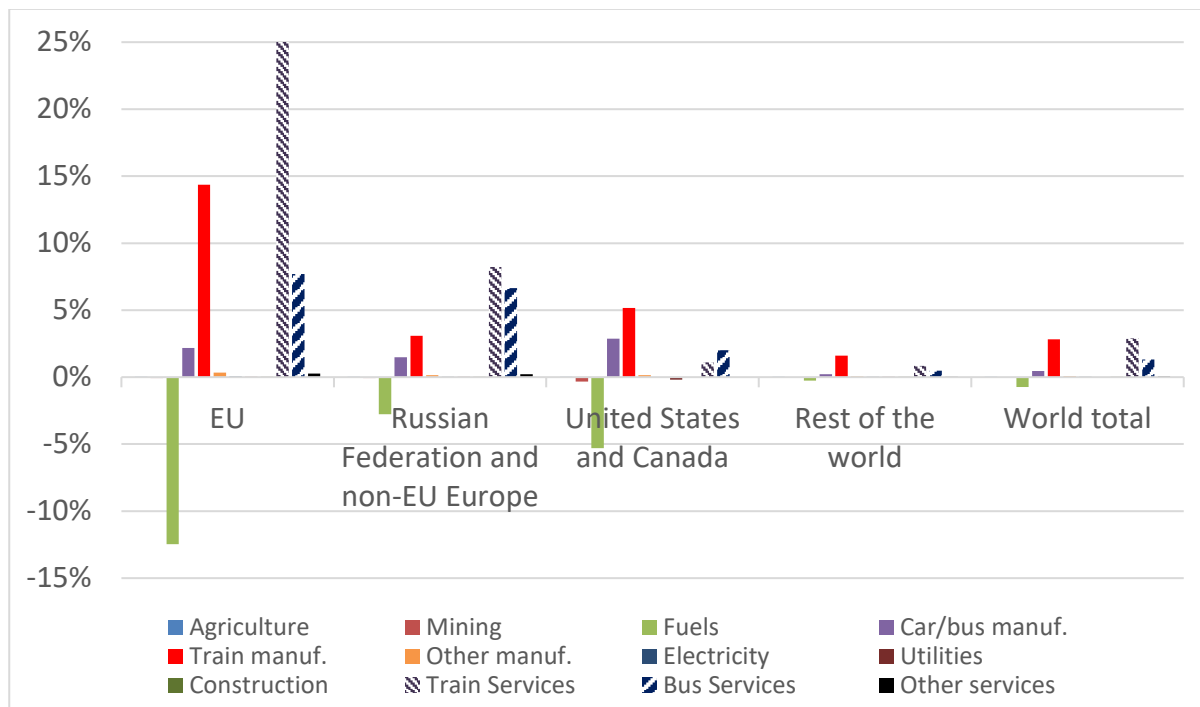
<sup>15</sup> It should be noted that for the purpose of modelling, the low and high estimates result from a 10 per cent higher or lower final demand for rolling stock and public transport services (in particular bus manufacturing, bus services, train manufacturing, train services and fuels).

projected generation of employment is much smaller (30,000 jobs in total for bus and railway services combined), which has to do with the currently lower level of service provision in those two countries. On the whole, close to 1.4 million additional jobs could be created in railway and bus services across the ECE region.

The train and bus manufacturing industries are projected to add between 2 and 15 per cent more jobs to their workforce across ECE countries – specifically, around 165,000 jobs in bus manufacturing and 340,000 jobs in train manufacturing. Employment gains are expected to be highest in the EU countries and in the United States and Canada because of their strong manufacturing base. As bus and car manufacturing are both part of the automotive industry, an overall rise in employment levels in the industry masks employment shifts from the production of cars to that of buses and coaches.

Employment losses in the fuel industry are expected to be significant across the ECE region, with a reduction of up to more than 10 per cent in the EU. Specifically, the EU would lose around 29,000 jobs, the United States and Canada around 23,000 jobs, and the Russian Federation and non-EU Europe around 55,000 jobs. These projections are based on the scenario’s assumption that additional investment in public transport is fiscally neutral and entirely paid for by taxes on vehicle use (i.e. on fuel consumption) and, to some extent, on the purchase of new vehicles. Tax-funded policies, such as those envisaged under the PT.1 scenario, tend to have smaller employment effects than debt-funded policies. While tax instruments typically reduce consumers’ and businesses’ demand for the taxed goods or services and redirect spending to other sectors, government borrowing or monetary expansion, at least in the short run, adds to aggregate demand without necessarily reducing consumption. The short- to medium-term employment effects may thus be greater if debt instruments are used to finance the expansion of green transport. However, debt eventually has to be serviced, potentially leading to longer-term negative employment effects. Raising taxes on fossil fuels, on the other hand, has the added bonus of reducing GHG emissions while promoting green transport and jobs.

**Figure 2.3. Difference in employment levels by industry between PT.1 scenario (investment in public transport doubled) and business-as-usual scenario, 2030 (%)**



Source: ILO estimates based on EXIOBASE version 3.

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Under the PT.1 scenario, a net total of about 4.8 million jobs would be added to world employment across all sectors, including 2.9 million jobs in the ECE region alone. Employment in the transport-specific sectors is projected to increase by 2.7 million jobs, with just over 1.8 million jobs created in the ECE region.

#### **D. Scenario PT.2: Free public transport**

The second scenario that we consider ties in with growing calls in ECE countries for public urban transport to be made free of charge. At present, public transport in many cities is funded in part by fares paid by users and in part by public subsidies financed through various local taxes and charges (e.g. urban tolls, congestion pricing, pollution charges, parking charges and fuel taxes or other charges for those who benefit the most from public transport, such as employers, retailers and real-estate owners). Funding can also come from public–private partnerships and/or secondary revenue streams (e.g. advertisement, retail space) (UITP, 2013b). To increase the attractiveness of public transport, a number of cities have explored the possibility of making it free for users; in some cases, such a policy has actually been adopted.

In France, the feasibility of providing free public transport in the Île-de-France region has been studied in a report commissioned by the President of the Île-de-France region and of the company Île-de-France Mobilités. The report reviews the current situation, evaluates the potential of free public transport, and provides some policy recommendations. Further details can be found in box 2.1 below.

##### **Box 2.1. Feasibility study on the provision of free public transport in Île-de-France**

Published on 2<sup>nd</sup> October 2018, the study considers why people prefer using cars to public transport, arguing that quality, rather than price, is the most important factor. Accordingly, free public transport would reduce car traffic by only 2 per cent, which means that the effects of such a policy on pollution levels and road congestion would be minimal. Moreover, the policy would lead to a reduction in the quality of public transport services as a result of increased overcrowding – the main reason why the existing modal share of public transport is low – and would not meet social equity goals, since it would disproportionately benefit those who can already afford public transport. These considerations against the introduction of free public transport are particularly weighty, given the significant level of investment required for this policy, which could create funding problems.

The report proposes alternatively to make public transport more efficient and thereby to increase its modal share. Generally speaking, it recommends, first, a more rational use of the car through the development of car-sharing schemes and the introduction of lower-polluting vehicles. Second, the report advocates an improved funding mechanism for public transport based on a progressive pricing system, which would be more equitable and would lighten the burden on taxpayers. Along these lines, some of the specific policies recommended are the expansion of the limited traffic zone in Paris, the prohibition of all diesel vehicles by 2024, the establishment of dedicated lanes for shared vehicles, and the reintroduction of distance as a factor in the determination of public transport fares.

If such recommendations are adopted, bold action to foster the use of public transport and reduce air pollution and congestion caused by road transport would help to achieve the objectives of the Urban Transport Plan for the Île-de-France Region for 2017–2020, leading to a more sustainable transport system.

Source: Committee on Free Public Transport in Île-de-France (2018).

Case studies of the provision of free public transport point to different effects on passenger demand, depending on the city, region and the current modal share of public transport, among other factors. Drawing on the evidence from relevant schemes that are in operation in Belgium, Estonia and the Netherlands (see

box 2.2), the PT.2 scenario developed for this report assumes that eliminating fares leads to a 14 per cent increase in demand for public transport. In the modelling of this scenario, this translates directly into a 14 per cent increase in the use of public transport, with no additional investment in infrastructure or rolling stock required because it is assumed that spare capacity exists to meet the additional demand.

### **Box 2.2. Free public transport in Belgium, Estonia and the Netherlands**

In 2013, Tallinn became the largest city to adopt fare-free public transport, the main objectives being to promote a modal shift towards public transport and to meet the mobility needs of vulnerable population groups. In 2012, ticket sales covered only one third of the system's operational costs, a lower share than other public transport systems in Europe. The immediate effect of the new scheme (three months after its launch) was a 1.2 per cent increase in passenger demand, to a large extent due to people switching from walking to public transport. One year after the launch, use of public transport had increased by 14 per cent, a comparatively low increase that can be ascribed to the already high market share of public transport (Cats, Susilo and Reimal, 2017).

In the Netherlands, the implementation of fare-free public transport on two bus routes in 2004 tripled passenger use within one year of the programme's launch – bus use on the free bus routes increased from 1,000 to 3,000 passengers a day. The growth of passenger traffic on these routes was driven by a modal shift from cars (45 per cent), bicycles (10 per cent), other public transport services (20-30 per cent) and new trips (16 per cent) (van Goeverden et al., 2006).

In Hasselt, Belgium, the introduction of a fare-free scheme resulted in an increase in demand for public transport driven by a modal shift from cars (16 per cent), bicycles (12 per cent), walking (9 per cent) and new trips (63 per cent) (van Goeverden et al., 2006).

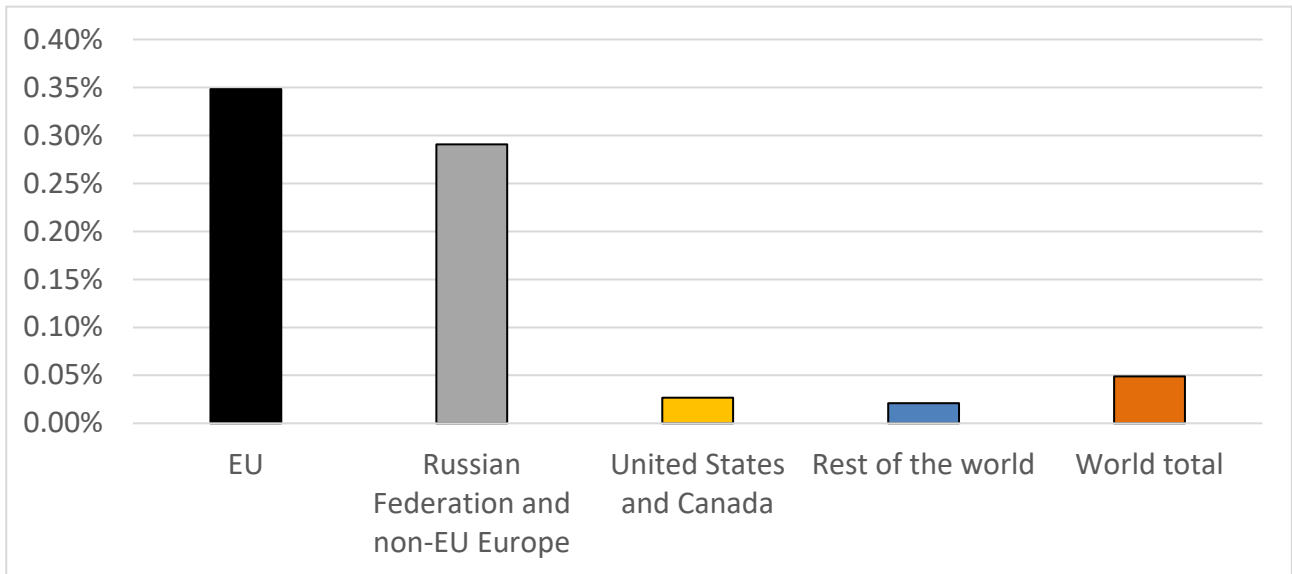
Of the total increase in the use of public transport under the PT.2 scenario, only 13 per cent is attributed to a modal shift away from car use. This is because, by and large, the elimination of fares seems to provide very limited incentives to car users to switch to public transport. In terms of financing, the scenario assumes that the revenue from public transport fares is replaced by an increase in household fuel prices (e.g. a fuel tax paid at the pump) and, to a lesser extent, by a specific tax on new vehicles, both of which have been shown to reduce car use and purchases of new cars.<sup>16</sup> As households no longer spend money on public transport, the savings accrued can be used for the consumption of other goods and services.

## **E. Projections of employment under the PT.2 scenario**

Comparison of the PT.2 scenario with the business-as-usual (baseline) scenario indicates that fare-free public transport would increase employment in the ECE region only marginally, namely by less than 0.35 per cent (figure 2.4). The reduction in demand and hence employment in the fuel industry as a result of the fuel tax used to fund fare-free public transport is outweighed slightly by the increase in employment in the public transport sector.

<sup>16</sup> Zeleke (2016) provides gasoline and diesel price elasticities for the EU countries. For non-EU countries in the ECE region, the scenario draws on Baranzini and Weber (2013), Havranek and Kokes (2015), Huntington, Barrios and Arora (2017) and Odeck and Johansen (2016). McCarthy (1996) provides price elasticities for new cars.

**Figure 2.4. Relative difference in employment levels between PT.2 scenario (free public transport) and business-as-usual scenario, 2030 (%)**

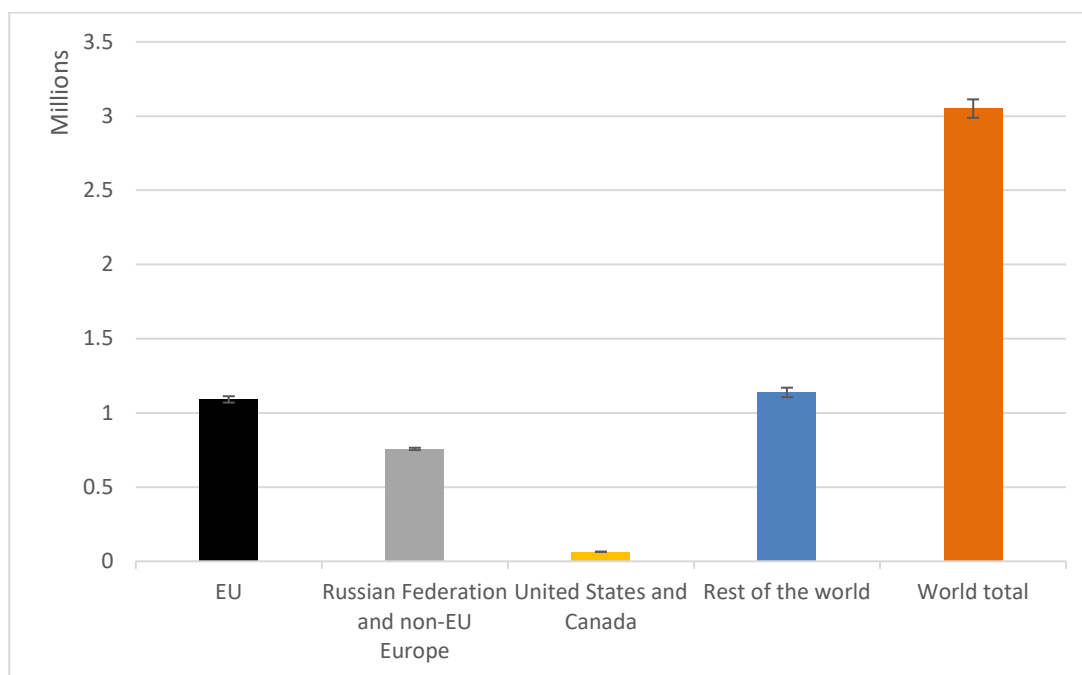


Source: ILO estimates based on EXIOBASE version 3.

Figure 2.5 shows the absolute difference in employment levels between the PT.2 scenario and the business-as-usual scenario. A net gain of almost 1.1 million jobs is expected in the EU, while the Russian Federation and non-EU Europe would gain almost 0.8 million jobs. These jobs are likely to be permanent, as they would be concentrated in the operation and maintenance of public transport. In the United States and Canada, there is no difference between the baseline and the PT.2 scenario as far as employment levels are concerned.

A 10 per cent increase or decrease in spending on public transport under the PT.2 scenario provides a range of low and high estimates for the projected employment levels (shown as error bars in figure 2.5). The difference between the two is small (just around 60,000 jobs across the world) because of the already small initial effect of fare-free public transport.

**Figure 2.5. Absolute difference in employment levels between PT.2 scenario (free public transport) and business-as-usual scenario, 2030 (million jobs)**

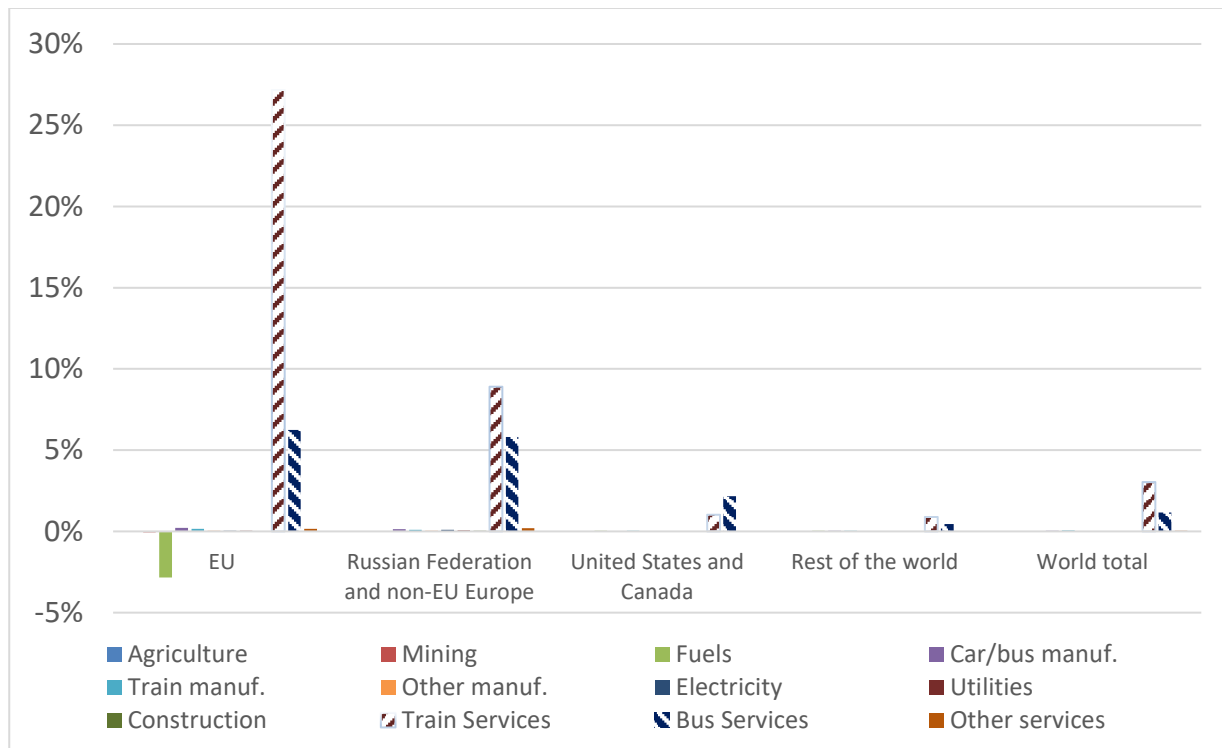


Source: ILO estimates based on EXIOBASE version 3. Whiskers represent high and low estimates.

Figure 2.6 displays the employment effects in each related sector under the PT.2 scenario. As expected, job creation is led by the public transport sector (specifically urban railway and bus services), where the majority of jobs are likely to be permanent. Railway and bus service jobs in the EU would increase by 27 and 6 per cent, respectively; by 1 and 2 per cent jobs in the United States and Canada; and by 9 and 6 per cent in the Russian Federation and non-EU Europe. This would result in the number of railway service jobs worldwide increasing by around 1.3 million, most of them permanent jobs. Because the PT.2 scenario does not assume additional construction of public transport infrastructure, the number of temporary jobs would be limited.

Job losses, which are projected to be lower than job creation both in the ECE region and globally, would be most pronounced in the fuel industry. The total employment effects in this scenario are small because there is no additional investment in public transport infrastructure or rolling stock. This also means that the financing needs of governments are much smaller than in the PT.1 scenario (doubling of investment in public transport). Similarly, the fuel tax that would need to be levied is lower and the reduction in car use and fuel consumption that would be achieved is limited.

**Figure 2.6. Difference in employment levels by industry between PT.2 scenario (free public transport) and business-as-usual scenario, 2030 (%)**



Source: ILO estimates based on EXIOBASE version 3.

Under the PT.2 scenario, a net total of about 3.1 million jobs would be added to world employment across all sectors, including 1.9 million in the ECE region alone. Employment in the transport-specific sectors is projected to increase by 1.9 million jobs, with just over 1.2 million created in the ECE region.

While the model used in this study does not allow us to determine exactly the cumulative effect of these two scenarios, a fair estimate is that at least 2.5 million jobs would be created in the transport sector in the ECE region if both investment in public transport were doubled and its use were made free of charge.

## F. The employment effects of expanding public transport up to 2050

Our evaluation of the employment effects of scenarios PT.1 and PT.2 has been based on running the scenarios until 2030 and comparing the projections with those under a business-as-usual scenario. It is difficult to make reliable projections beyond 2030 because of the uncertainty over future economic and employment trends, which may be driven by new technologies and policies. Nevertheless, barring any radical change in mobility patterns by 2050, such as autonomous driving, it is likely that the small but positive effects of the expansion of public transport on employment in that sector projected up to 2030 would continue towards 2050. In addition, a part of the employment implication of public transport expansion results from financing mechanisms – if the financing scheme shifts the demand in sectors with lower labour intensity towards sectors with higher labour intensity (e.g. fuels versus public transport services), the total employment effect will be positive.

The expansion of public transport also entails investment in construction and in rolling stock. The extent to which the value chains for these two sectors remain within a particular country is key to understanding their employment effects. Jobs in infrastructure development are likely to remain within the country but to be of a short-term or temporary nature, apart from jobs that have to do with maintenance of the transport



network. The servicing of an expanded public transport sector will create long-term jobs, as will the manufacture of the rolling stock required, benefiting countries that currently have a strong manufacturing base. Countries looking to expand public transport while maximizing the employment benefits should ensure that the value chains for the construction of physical infrastructure and the manufacture of rolling stock remain within their national borders as far as possible.

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### **3. The employment effects of electrifying private passenger and freight transport in the region of the Economic Commission for Europe**

The scenarios considered in this chapter are informed by policies recently adopted in ECE countries (e.g. France and the United Kingdom) and in Asia (notably China) to significantly reduce the use of, or even ban, vehicles with an internal combustion engine. It is widely acknowledged that the electrification of both private passenger and freight transport can make the transport sector more sustainable, especially when the electricity to power the new vehicles is generated from renewable energy sources. Less well understood is the way in which the production, maintenance and use of electric vehicles are likely to alter global production structures and value chains and affect employment in different sectors and regions.

When preparing the present study, a number of possible electrification scenarios were initially discussed by the ECE and the ILO. As a result of these discussions, which were later joined by the Partnership on Jobs in Green and Healthy Transport and by the Steering Committee of THE PEP, the following scenarios were identified:

- Electrification 1 (E.1): Ban on internal combustion engines in private passenger vehicles in cities;
- Electrification 2 (E.2): Introduction of a requirement for all public transport vehicles to have no internal combustion engines;
- Electrification 3 (E.3): Introduction of a voluntary or mandatory target of 50 per cent of all vehicles manufactured to be fully electric;
- Electrification 4 (E.4): Ban on internal combustion engines for light commercial vehicles.

The ILO modelling team subsequently analysed the viability of each of these scenarios. It turned out that E.1 would give the same results as E.3, and that the modelling of E.2 was not feasible. Consequently, only E.3 and E.4 were selected for modelling.

These two scenarios were developed for the ECE region and projections up to 2030 obtained to establish the impact that the electrification of private transport would have on employment within the region and across the world. The two scenarios were compared with the business-as-usual scenario using the same multiregional input–output model that was discussed in Chapter 2.

#### **A. The electrification of private passenger and freight transport and its employment effects**

The electrification of private passenger and freight transport can enhance energy efficiency and energy security, and reduce the transport sector's carbon and environmental footprint, especially when the electricity to power new types of vehicles is generated from renewable energy sources. The widespread adoption of electric vehicles in the ECE region would lead to direct, indirect and induced employment effects in the region and beyond, since the value chain for the manufacture, operation and maintenance of such vehicles cuts across geographical and sectoral boundaries and differs significantly from that of vehicles with an internal combustion engine (ICE).

Overall, electric vehicles require less manufacturing, maintenance and repair labour than ICE vehicles because their engines have fewer moving parts (UBS Research, 2017). Although certain parts are the same as in ICE vehicles, electric vehicles rely on batteries and a greater number of electrical components. Among the activities in the corresponding supply chains are the extraction and purification of copper, lithium, cobalt and nickel (*ibid.*). The replacement of ICE vehicles by electric vehicles in private passenger transport would bring about job gains in certain sectors (e.g. electricity generation, battery manufacturing, the production of electrical parts and machinery, charging station infrastructure) and job losses in others (e.g. fuel production

and refinery, retail sale of automotive fuel, repair of motor vehicles) (ECF, 2018). Furthermore, the lower maintenance costs and longer life cycles associated with electric vehicles, in addition to smaller outlay on fuel, would allow households to spend more money on other goods and services, which would in turn increase demand and activate employment in those sectors.<sup>17</sup>

A rapid shift to low-emission private transport in the EU, notably through the adoption of battery-powered and hybrid electric vehicles, has the potential to generate a net employment gain of between 850,000 and 1.1 million jobs in Europe by 2030 (ibid.). Although the production of batteries for electric vehicles requires less labour input than the production of ICE vehicles, hybrid electric engines are more labour-intensive. The scenarios explored by ECF (2018) envisage the use of different technologies to achieve a European car fleet by 2030 that is made up of at most 50 per cent ICE vehicles; the scenarios vary depending on the share of new ICE vehicles sold and on the technology underlying the remaining vehicles (distributed between plug-in hybrid, hybrid, battery electric, and fuel cell electric vehicles). In all these scenarios, job creation is driven by employment in the construction, electricity, hydrogen, services and manufacturing sectors,<sup>18</sup> but there would be job losses in such sectors as the manufacturing of conventional vehicles, petroleum and gas (FTI Consulting, 2018). Box 3.1 below looks at the employment impacts of different low-carbon vehicle technologies.

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<sup>17</sup> The greater energy efficiency and lower operating and maintenance costs of electric vehicles could lead to a rebound effect, prompting people to use their cars more often. The “rebound effect” of transport efficiency, particularly with regard to passenger vehicles, has been studied by Aasness and Odeck (2015) and Vivanco et al. (2014). If the rebound effect is dominant, it will increase employment in the manufacture and maintenance of electric vehicles, and in related sectors, but also increase congestion, electricity use and the private sector’s carbon footprint because part of the car fleet would still continue to be powered by fossil fuels. Accounting for the rebound effect is beyond the scope of this report. We assume that it is minimal, and that energy efficiency will increase the disposable income of households, stimulating economic activity and employment in other sectors (induced effects).

<sup>18</sup> Anticipating the skills demand for electric vehicle-related manufacture and services, the EU-funded project “e-gomotion” (2011–2013), which was directed at secondary school students, sought to raise awareness of opportunities brought by the electrification of road transport.

### **Box 3.1. The employment effects of low-carbon vehicle technologies in Europe**

The two scenarios considered in this chapter (E.3 and E.4) are used to estimate the employment impacts of policies designed to increase the uptake of fully electric vehicles. However, other types of low-carbon vehicle can also help significantly to reduce emissions of carbon dioxide and other pollutants, and to achieve energy efficiency gains and net job creation in the ECE region. These include hybrid electric vehicles (HEVs), plug-in hybrid electric vehicles (PHEVs) and fuel cell electric vehicles (FCEVs).

One of the main employment impacts of a shift away from ICE vehicles in the ECE region is linked to a drop in the demand for petroleum and diesel, which consequently decreases the region's dependence on fossil fuel imports and increases demand for domestically produced hydrogen or electricity. Indeed, European countries and many other countries in the ECE region (exceptions include the Russian Federation and a few Central Asian economies) are net importers of oil. Europe is also a net exporter of cars and car parts to other parts of the world (ECF, 2018).

A transition to low-carbon vehicles would result in the deployment of more charging and refuelling infrastructure, and alter the interactions between the transport and the power system within the domestic economy (ibid.). In addition, although non-European companies hold a significant share of the market for electric vehicles, most of their cars are produced in Europe (ibid.). Increased uptake of low- and zero-carbon vehicles would therefore maintain or generate more economic activity and jobs within the European economy.

Studying four different policy and technology development scenarios, ECF (2018) estimates that between 501,000 and 1.1 million net additional jobs could be generated in Europe by 2030 as a result of this transition, and that between 1.4 and 2.3 million net additional jobs would be created by 2050. In particular, under a scenario where a car fleet consisting of 50 per cent ICE vehicles and 50 per cent HEVs is achieved by 2030, 286,000 direct and indirect jobs would be created in the automotive industry value chain, while 374,000 jobs would be created through avoided oil use in the economy as a whole. Under a more ambitious scenario where the fleet consists of 5 per cent ICE vehicles, 15 per cent HEV, 45 per cent PHEVs, 20 per cent BEVs and 15 per cent FCEVs by 2030, 591,200 direct and indirect jobs would be created in the automotive industry value chain and 508,800 jobs through avoided oil use. Hence, a transition of the transport sector towards a variety of low- and zero-carbon vehicles (not only fully electric ones) would create many new jobs, significantly reduce the carbon footprint of the automotive industry, and increase energy security.

Several studies conducted in the United States have projected net employment gains as a result of switching to electric vehicles, although the estimates differ depending on the market penetration that is assumed for such vehicles. Positing a scenario in which plug-in electric vehicles (PEVs) account for 40 per cent of the US household market for light-duty vehicles and 20 per cent of miles travelled are electric, Winebrake and Green (2009) estimate that the reduction in gasoline demand and household expenses would create between 162,000 and 863,000 jobs in the country. Projecting a large PEV market share, Melaina et al. (2016) estimate that fuel savings resulting from the adoption of PEVs could lead to an annual average employment gain of up to 147,000 jobs during the period 2015–2040, which would be driven by household fuel savings, reductions in petroleum imports and increased domestic consumption of electricity.

### **Box 3.2. The promotion of e-mobility and alternative vehicles in Austria**

Austria's "klima:aktiv mobil" programme launched in 2004 is one of the best examples illustrating the employment effects of e-mobility and alternative vehicles. The initiative supports Austria's businesses, cities, municipalities and regions in promoting clean mobility with the ultimate objective of reducing GHG emissions.

Under the programme, financial support is provided to businesses for the implementation of climate-friendly mobility projects, the use of electric vehicles and vehicles powered by sustainable biofuels, eco-driving, cycling projects and the development of the necessary infrastructure (Federal Ministry for Sustainability and Tourism, 2018).

In addition to providing financial support, the programme also pursues a broader strategy for transformation of the market. The transition to climate-friendly mobility calls for a workforce with specific skills, and so suitable training programmes have been closely coordinated with measures to develop the market for green product and green jobs. Consequently, the initiative includes awareness-raising for, and consultations with, specific target groups, partnerships, and training and certification.

The programme has led to an increase in the number of newly registered battery electric vehicles (an increase of 42 per cent in 2017 compared with 2016), the launching of 11,600 climate-friendly mobility projects, the training of about 2,000 competence partners (e.g. Eco-Driving trainers, bicycle technicians and youth mobility coaches) and the certification of 34 klima:aktiv mobil driving schools. The programme has also created approximately 6,000 green jobs, and it is estimated that by 2020 there will be 15,000 such jobs in the transport sector (ibid.).

The existing literature indicates that the electrification of private transport will have both positive and negative impacts on employment. Moreover, there will be direct, indirect and induced effects, their intensity varying depending on the country. A direct effect is the creation of jobs associated with the manufacture of electric vehicles and the generation of electricity to power them. These two activities have indirect effects through the corresponding supply chains. Furthermore, given that electricity is cheaper than gasoline or diesel for households and businesses, the ensuing increased consumption of other goods and services will lead to induced effects. At the same time, demand for ICE vehicles and their inputs, for fossil fuels and for related services is reduced. Oil-producing and refining countries will be faced with a reduction in jobs in these industries. Countries, such as China, with a strong industrial base in electric components and machinery stand to benefit from the growing adoption of electric vehicles worldwide. On the other hand, countries with a strong automotive industry based on ICE vehicles that fail to seize opportunities to switch to the production of electric vehicles would face the reallocation of jobs to countries in the vanguard of electric transport.

On the whole, the scenarios point to positive employment effects from the electrification of private transport, with job creation being concentrated in the development and manufacture of electrical equipment and battery technology, and also in the construction of infrastructure and in electricity generation. Although the manufacture of electric vehicles is less labour-intensive than that of ICE vehicles, the industries related to the former, if considered together, tend to employ more people than the industries that are set to decline. Through our modelling of scenarios E.3 and E.4 we have identified the sectors in which job losses and reallocation are likely to occur: measures will be required to support the workers and communities affected. We have also identified the sectors that will benefit the most from the electrification of private cars in the ECE region: policy efforts should be undertaken to develop these industries and ensure that the job creation potential associated with electrification stays in the region.

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**B. Scenario E.3: Introduction of a voluntary or mandatory target of 50 per cent of all vehicles manufactured to be fully electric**

This scenario reflects ECE countries' interest in, and implementation of, pilot regulations specifying that a certain proportion of new cars sold should be zero-emission vehicles (see box 3.1). The scenario envisages the introduction of a voluntary or mandatory target of 50 per cent of all vehicles produced to be fully electric across all countries in the ECE region by 2030. The adoption of such a policy would make it clear to car manufacturers and other stakeholders that a long-term shift from the production of mainly ICE vehicles to electric vehicles is to be expected. We analyse the employment effects of the changing input structure of car production and car use by comparing the scenario with a business-as-usual scenario.

Under this scenario, projected ICE vehicle production in the ECE region is replaced by electric vehicles. The production structure of car manufacturing is altered to reflect the higher content of electrical parts and batteries, which altogether account for up to 50 per cent of production costs. The employment requirements for the production of electric vehicles are also taken into account (UBS Research, 2017).

It is further assumed that electric cars are perfect substitutes for ICE vehicles, and that the ECE region will retain its share of global car sales. This is a bold assumption, given that Asian markets are currently leading the electric vehicle market. Industrial policy in the ECE region would have to be adjusted if it is to retain its current share of global car manufacturing in a future dominated by electric vehicles. The model, however, also assumes that the international trade structure regarding the inputs for the manufacture of both electric vehicles and ICE vehicles will remain the same. For example, a majority of electric components and batteries are currently imported from Asia, and this relative trade share is assumed to remain constant when analysing the employment effects related to supply chains and vehicle production.

### **Box 3.3. The adoption of regulatory mandates on zero emission vehicles**

A mandate on zero emission vehicles (ZEVs) was first adopted in California (United States) in 1990 as part of the California Air Resources Board's Low-Emission Vehicle Regulations. Manufacturers with ZEV sales above a certain threshold (measured as a percentage of their sales of conventional vehicles) are awarded "ZEV credits". The system allows manufacturers to bank their credit surpluses for later use, transfer credits, and make up credit shortfall within specified time frames.<sup>19</sup> The policy, though criticized and modified several times over the years, has contributed to an increase of ZEV sales and the development of low-emission vehicle technologies in California (California Air Resources Board, 2018; US Energy Information Administration, 2017). The minimum ZEV credit requirement, for example, was 2 per cent in 1998. It will increase to 9.5 per cent in 2020 and to 22 per cent in 2025 (California Air Resources Board, 2018).

California's ZEV mandate has been adopted in nine other states: Connecticut, Massachusetts, Maryland, Maine, New Jersey, New York, Oregon, Rhode Island and Vermont. In Canada, Quebec became the first province to adopt the mandate in early 2018. Quebec's mandate requires carmakers to ensure that 15 per cent of their sales are ZEVs (either electric or hydrogen-powered) by 2025. These 11 regional governments, together with Germany, the Netherlands, Norway and the United Kingdom, make up the International Zero-Emission Vehicle Alliance, which seeks to reduce GHG emissions from the transport sector by accelerating the deployment of ZEVs. The members of the Alliance have set themselves the goal of ensuring as quickly as possible – and no later than 2050 – that all passenger vehicles in their jurisdictions are ZEVs (ZEV Alliance, 2015).

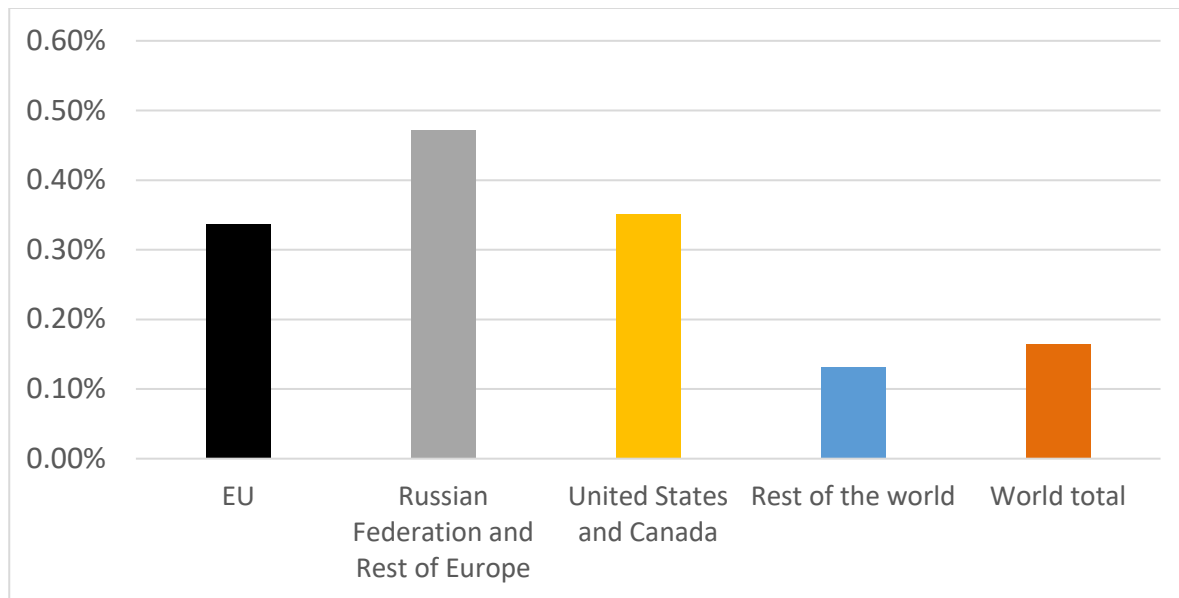
## **C. Projections of employment under the E.3 scenario**

The requirement for electric vehicle production in the ECE region to be 50 per cent of total production by 2030 would lead to worldwide net job creation of close to 0.2 per cent, or around 10 million jobs, compared with a business-as-usual scenario. As shown in figure 3.1, as a result of such a mandatory or voluntary target, employment is expected to be 0.34 per cent higher in the European Union, 0.47 per cent higher in the Russian Federation and non-EU Europe, and 0.35 per cent higher in the United States and Canada.

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<sup>19</sup> For a detailed calculation of ZEV credits, see US Energy Information Administration (2017).

**Figure 3.1. Relative difference in employment levels between E.3 scenario (50 per cent of vehicles manufactured to be fully electric) and business-as-usual scenario, 2030 (%)**



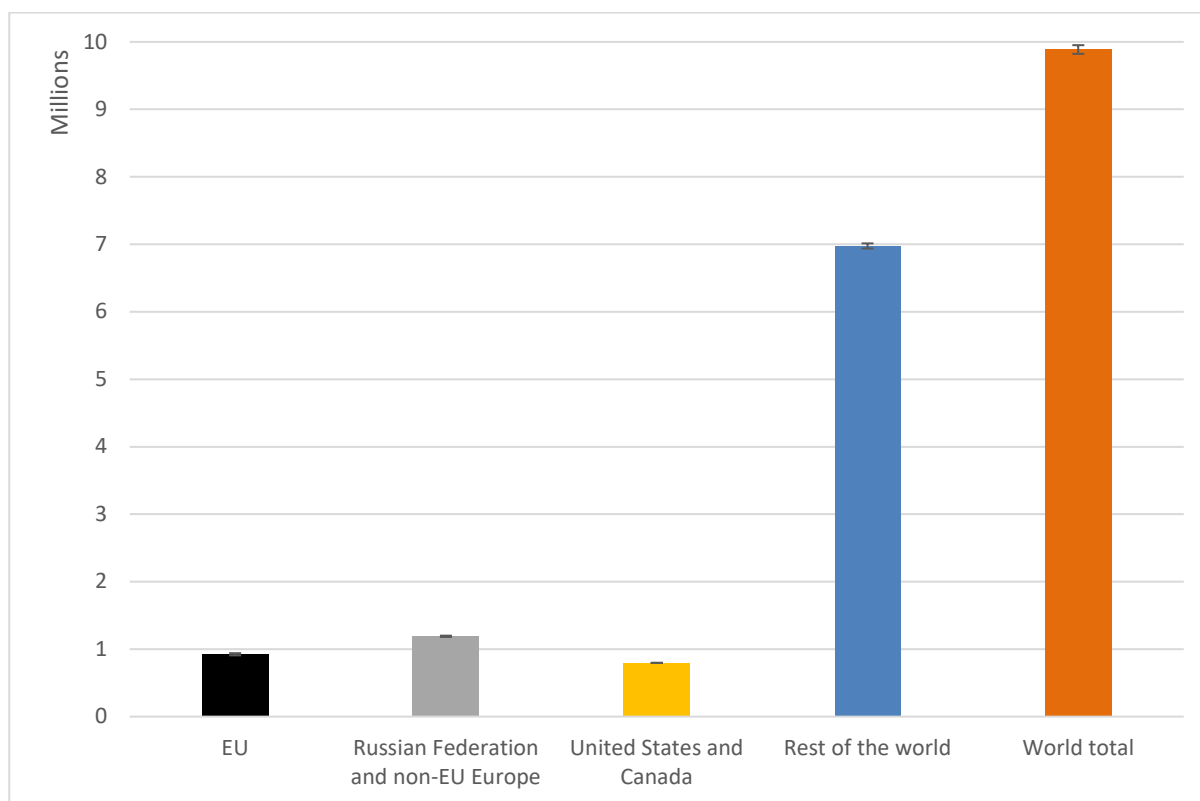
Source: ILO estimates based on EXIOBASE version 3.

As can be seen from figure 3.2, the majority of jobs (around 7 million) are expected to be created outside the ECE region. This is because the scenario assumes a continuation of the current trade structure, including the comparative advantage that Asia currently enjoys in the manufacturing of electric components and batteries. The new jobs created are likely to be permanent and middle-skilled occupations in the manufacture of electrical machinery and vehicles.

There would be around 0.9 million new jobs in the European Union, almost 1.2 million in the Russian Federation and non-EU Europe, and close to 0.8 million in the United States and Canada. In order to account for uncertainties and obtain high and low estimates, the parameters used in the scenario were modified by increasing or reducing final demand for vehicles and electrical machinery, along with associated electricity and fuel consumption, by 10 per cent. The difference between high and low estimates at the global level is around 65,000 jobs; for countries outside the ECE region (rest of the world), it is around 40,000 jobs. Said difference in the ECE region is much lower (16,000 jobs in the European Union, 10,000 in the Russian Federation and non-EU Europe, and less than 1,000 in the United States and Canada) because, as noted before, electric components and batteries are imported mainly from outside the ECE region, notably Asia, and also because job gains and losses in various sectors tend to cancel each other out in the ECE region.



**Figure 3.2. Absolute difference in employment levels between E.3 scenario (50 per cent of vehicles manufactured to be fully electric) and business-as-usual scenario, 2030 (million jobs)**

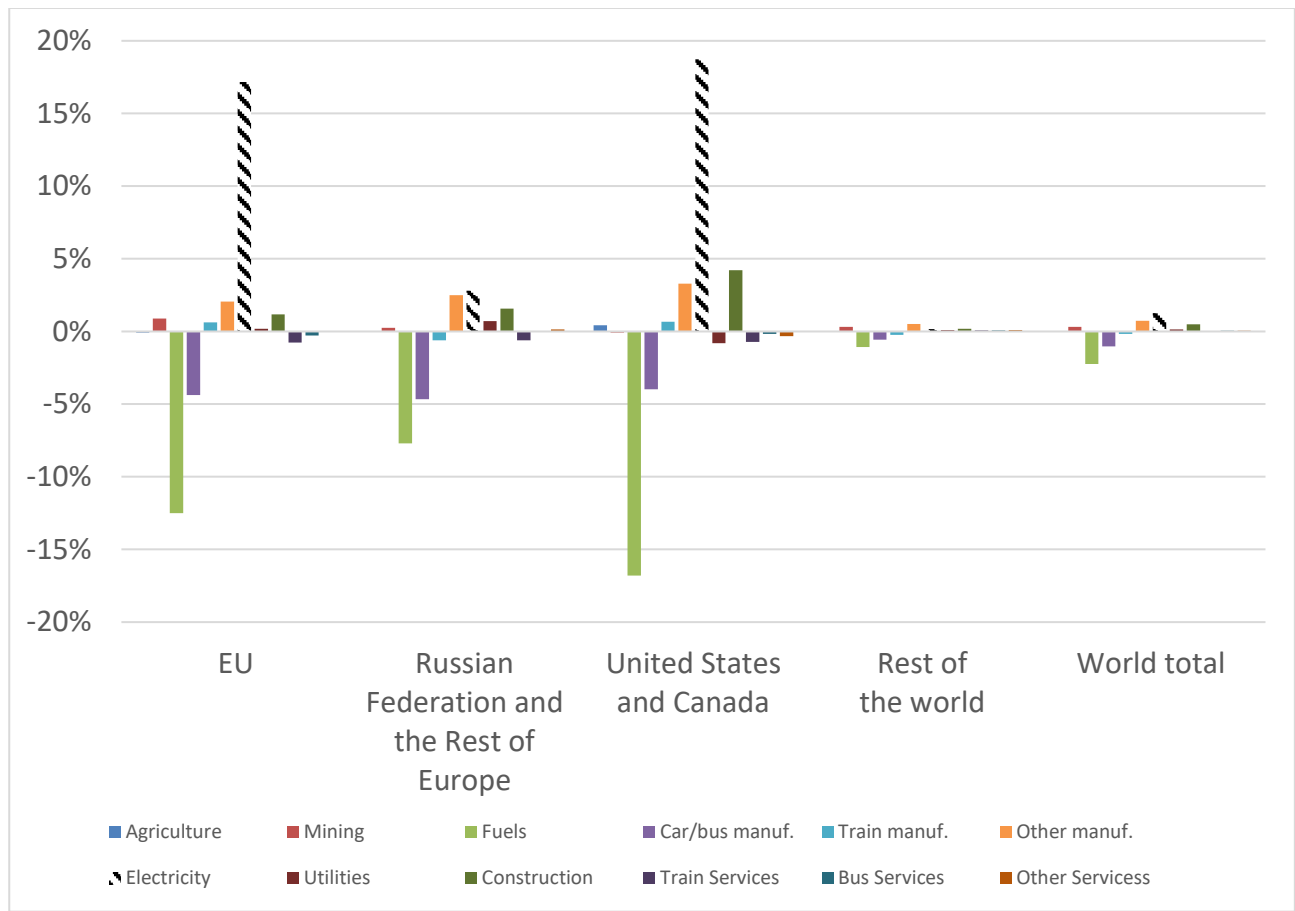


Source: ILO estimates based on EXIOBASE version 3. Whiskers represent high and low estimates.

The expansion of the electric vehicle industry under this scenario activates employment throughout the global value chain. Once the vehicles are on the market and start to be used, a reduction in fuel consumption by households and an increase in electricity demand will occur, further altering the production structure and employment distribution in individual countries. Because of the interlocking value chains, total job creation in the ECE region is also driven by the generation of electricity (from renewables and fossil fuels<sup>20</sup>) and by spending redirected from fuel consumption. As a result of the higher demand for electricity, including electricity generated from renewable sources, the construction sector can expect to experience job creation as well. Outside the ECE region, employment is expected to grow in the manufacture of electrical machinery, in construction and in the mining of copper ores. Figure 3.3 shows the employment effects for each industrial sector.

<sup>20</sup> The E.3 scenario assumes that the electricity production mix will follow the historical trends and projections for the business-as-usual-scenario up to 2030.

**Figure 3.3. Difference in employment levels by industry between E.3 scenario (50 per cent of vehicles manufactured to be fully electric) and business-as-usual scenario, 2030 (%)**



Source: ILO estimates based on EXIOBASE version 3.

By contrast, job losses across the world are concentrated in the manufacture of motor vehicles and in the petroleum extraction and refinery sectors. Across the ECE countries, some 355,000 jobs could be lost in the ICE vehicle manufacturing industry, with the biggest losses occurring in the United States and Canada (168,000), followed by the EU (132,000) and the Russian Federation and non-EU Europe (55,000).

Some job losses are expected to occur in the services sector in the EU and North America, largely owing to the linkages between that sector (maintenance and repair) and the car manufacturing industry and, to a lesser extent, also as a result of the reduction in value added across these economies. Indeed, car manufacturing is more closely linked to the services sector than the manufacture of electrical machinery, and the loss in value added feeds back into a reduction in household spending on services. Conversely, the increase in value added outside the ECE region leads to an increase in the demand for services there.

Under this scenario, households' demand for fossil fuels decreases, replaced by higher demand for electricity. However, GHG emissions may not be reduced proportionally because many countries still rely on fossil fuels to produce the electricity that powers electric vehicles. In addition, the production of electrical machinery for electric vehicles also entails GHG emissions. (The business-as-usual energy mix is assumed to continue in the E.3 scenario.) However, if coherence between transport and climate policies is pursued, then ensuring that electric transport relies on renewable energy would reduce emissions and stimulate employment in the renewable energy sector.

Under the E.3 scenario, a net total of about 9.9 million jobs would be added to world employment across all sectors, including 2.9 million jobs in the ECE region alone. Employment in the transport-specific sectors is projected to increase by 0.7 million jobs, with about 0.6 million jobs created in the ECE region.

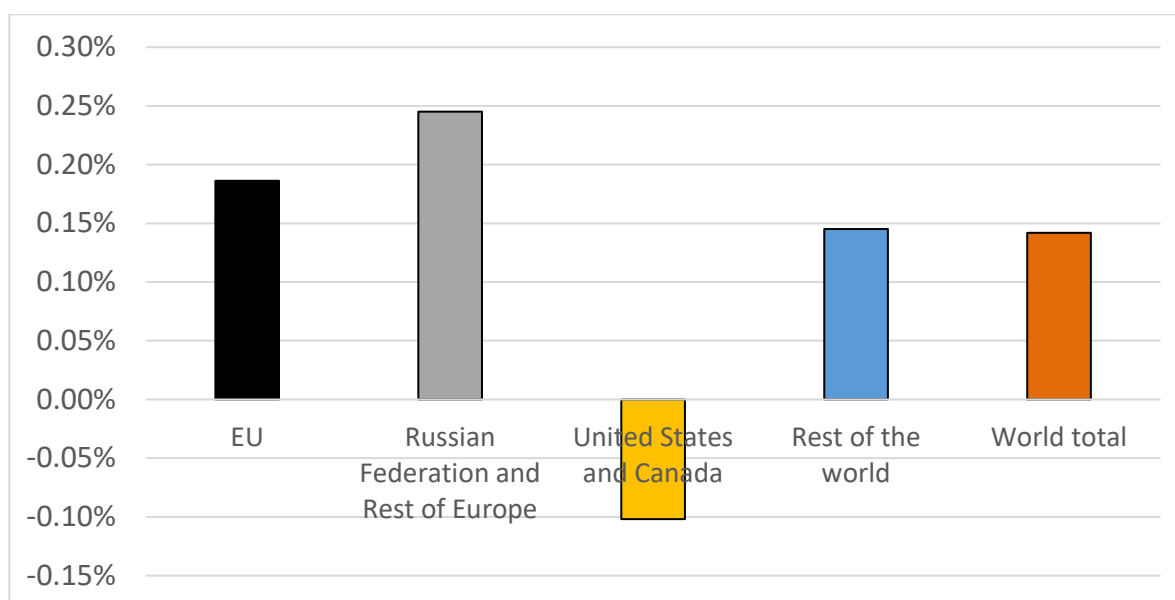
#### D. Scenario E.4: Ban on internal combustion engines for light commercial vehicles

This scenario is an extension of the E.3 scenario and focuses on light commercial vehicles. It envisages a complete ban on ICEs for such vehicles taking full effect in 2030, and assumes that the overall demand for vehicles and vehicle use do not change as a result of the policy, but that the latter encourages commercial transport to shift towards electric vehicles in the same way that the E.3 scenario reduces the use of private ICE vehicles. However, since the levels of global and regional production and use of light commercial vehicles vary (e.g. the share of such vehicles is much higher in the United States and Canada), the employment effects are expected to be different across the world. As in the E.3 scenario, such a policy would lead to positive local externalities in all countries, and help to reduce air and noise pollution in cities. It could also contribute to a reduction in GHG emissions, especially if the electricity to power the new vehicles comes from renewable energy sources, as discussed above.

#### E. Projections of employment under the E.4 scenario

Our modelling of this scenario indicates that world employment in 2030 would be almost 0.15 per cent higher than in a business-as-usual scenario, 0.19 per cent higher in the EU and 0.25 per cent higher in the Russian Federation and non-EU Europe. A small reduction in employment, of around 0.10 per cent, is expected in the United States and Canada, apparently owing to the high share of commercial vehicles in the total car stock, which would need to be replaced through the increased import of electric commercial vehicles (figure 3.4).

**Figure 3.4. Relative difference in employment levels between E.4 scenario (100 per cent of light commercial vehicles to be fully electric) and business-as-usual scenario, 2030 (%)**

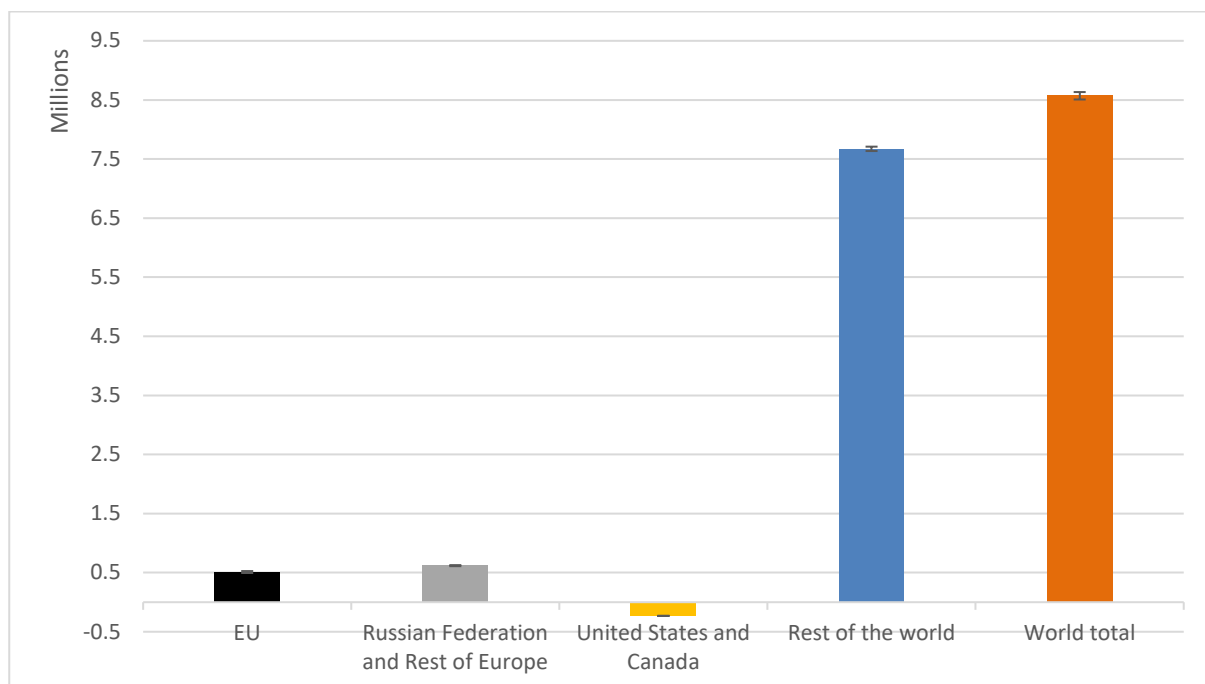


Source: ILO estimates based on EXIOBASE version 3.

Figure 3.5 shows the absolute difference in the number of jobs between the business-as-usual and E.4 scenarios by 2030. Net employment creation is expected to reach around 8.5 million jobs across the world, with around 0.5 million created in the EU, almost 0.7 million in the Russian Federation and non-EU Europe, and almost 8 million outside the ECE region (rest of the world). The new jobs created are likely to be permanent and middle-skilled occupations in the manufacture of electrical machinery and vehicles.

The strong job creation outside the ECE region is driven by the current trade and production structure in which most electric components and batteries are imported from Asia. Since it is assumed that the Asian electric industry will retain its comparative advantage up to 2030, the vigorous pursuit of electrified transport by ECE countries would result in most of the related employment being generated outside the region. In order to account for uncertainties and obtain high and low estimates, the parameters used in the scenario were modified by increasing or decreasing final demand for vehicles, electrical machinery and associated electricity and fuel consumption by 10 per cent. The difference between high and low estimates is highest outside the ECE region, at around 37,000 jobs. The adoption of appropriate industrial policies by ECE countries could alter the share of global electric components and of battery and machinery production and result in different employment outcomes.

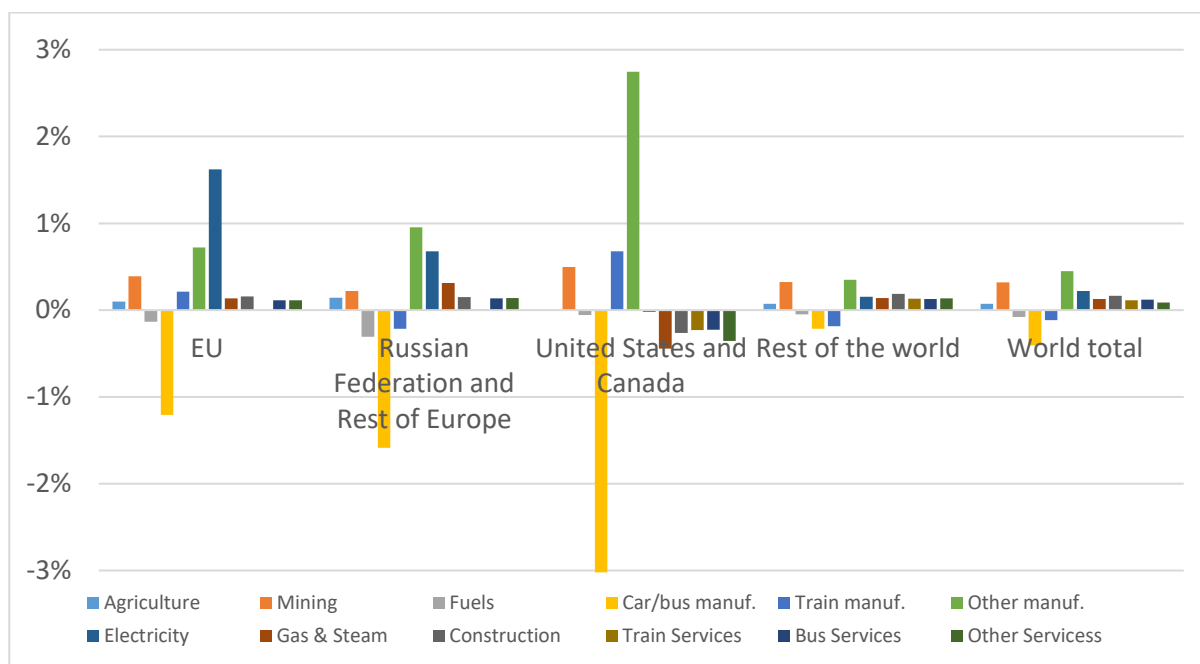
**Figure 3.5. Absolute difference in employment levels between E.4 scenario (100 per cent of light commercial vehicles to be fully electric) and business-as-usual scenario, 2030 (million jobs)**



Source: ILO estimates based on EXIOBASE version 3. Whiskers represent high and low estimates.

Reflecting the global trade structure, the employment effects vary significantly across industries and regions (figure 3.6). Job creation in the ECE region, though small, is led by the electricity sector, followed by manufacturing activities that are not directly related to transportation: since this scenario would result in a higher added value across the economy, particularly in European countries, household consumption of goods and services from other (non-transport specific) industries would increase. Job destruction in the ECE region would occur mainly in the manufacture of motor vehicles because the production of electric vehicle is less labour-intensive, as well as in the value chains associated with ICE vehicles. Some 36,000 jobs are projected to be lost in the EU, 50,000 in the United States and Canada, and 57,000 jobs in the Russian Federation and non-EU Europe.

**Figure 3.6. Difference in employment levels by industry between E.4 scenario (100 per cent of light commercial vehicles to be fully electric) and business-as-usual scenario, 2030 (%)**



Source: ILO estimates based on EXIOBASE version 3.

Under the E.4 scenario, a net total of about 8.6 million jobs would be added to world employment across all sectors, including 0.9 million jobs in the ECE region alone.

## F. The employment effects of electrifying private passenger and freight transport up to 2050

As with the scenarios for the expansion of public transport, projecting the employment impacts of transport electrification beyond 2030 is difficult because of the considerable uncertainty surrounding the technology and policy choices that will be made after that point. Apart from a projected further expansion of the electric car fleet, which would continue or accentuate the trends identified above, certain other factors will shape the employment effects of electrification in the years up to 2050.

The lifespan of lithium ion batteries, a key component of electric vehicles, is limited to 8–10 years, and their growing use has raised concerns about future waste management (Winslow, Laux and Townsend, 2018). Between 2030 and 2050, the batteries in electric vehicles produced today will need to be discarded and replaced. Unless alternative energy storage devices are invented, a large number of lithium ion batteries will enter the waste stream after 2030. The disposal or recycling of these batteries would create employment opportunities in the vehicle disassembly and waste management sectors up to and beyond 2050.<sup>21</sup> In addition, there is likely to be growing demand for the construction of recycling infrastructure to recover high-value materials from multiple battery chemistries (Richa et al., 2014), and for research and development work on waste collection and repurposing technologies.

The E.3 and E.4 scenarios assume constant labour productivities. However, as the manufacture of electric vehicles – currently still an emerging industry – becomes more established, labour productivity will probably

<sup>21</sup> On the basis of projections, obtained from various sources, of worldwide sales of electric vehicles, Richa et al. (2014) estimate that the waste stream of lithium ion batteries could amount to between 0.83 and 2.97 million packs per year by 2040, with 27 to 35 per cent coming from all-electric vehicles and plug-in hybrid electric vehicles and the remaining 73 to 65 per cent from hybrid electric vehicles.

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increase in the years up to 2030. Although the growing demand for electric vehicles will continue to generate new jobs, the job creation rate is set to decline as labour productivity increases. The two scenarios also assume that there will be no behavioural changes apart from those linked to current consumption elasticities, which is not realistic. Policies prompting people to reconsider their attitude to travel and encouraging a cultural shift away from motorization towards cycling and walking can further promote the electrification of transport (Brand, Anable and Morton, 2019).

## 4. Conclusions

Pursuing the goal of an environmentally sustainable and inclusive society requires a structural transformation of the economy, including both changes in the products and services on offer and changes to production processes (Bowen, Duffy and Fankhauser, 2016; Bowen and Kuralbayeva, 2015). This structural transformation, which would include the transport sector as well, has the potential to create decent work and protect workers and their families if accompanied by suitable policies (ILO, 2015a; Salazar-Xirinachs, Nübler and Kozul-Wright, 2014).

A transition to green and healthy transport will not necessarily result in positive employment outcomes in all industries: it is expected to lead to job losses in fossil fuel-based industries and value chains, while creating opportunities in other sectors. When seeking to promote sustainability in the transport sector it is important also to pay attention to employment outcomes and to policies that support job creation and decent work.

In this report we have studied the employment impact of two possible approaches to increasing the sustainability of transport. The methodology that we have used, which is based on a multiregional input-output table (EXIOBASE), has the advantage of making it possible to estimate not only employment effects in the transport sector but also the indirect effects that a transition to green transport would have in all other sectors of the economy.

Our analysis suggests that employment opportunities would indeed be opened up by a transition to green and healthy transport in the ECE region involving the increased use of public transport and the electrification of private passenger and freight transport. The scenarios we assessed were the following:

- For public transport:
  - PT.1: Doubling investment in public transport;
  - PT.2: Free public transport.
- For electrification:
  - E.3: Introduction of a voluntary or mandatory target of 50 per cent of all vehicles manufactured to be fully electric;
  - E.4: Ban on internal combustion engines for light commercial vehicles.

Stimulating the use of public transport by doubling investment (scenario PT.1) and making public transport free (scenario PT.2) could create at least 2.5 million additional jobs in the transport sector worldwide. This increases to at least 5 million jobs if the wider impact on other sectors of the economy is considered. More than half of these new jobs would be in the ECE region alone.

The introduction of a voluntary or mandatory target of 50 per cent of all vehicles manufactured to be fully electric (scenario E.3) would result in a net total of almost 10 million jobs being added to world employment across all sectors, of which 2.9 million would be in the ECE region alone. If we take just the transport sector, it is estimated that employment will increase by 0.7 million jobs, of which about 0.6 million jobs would be in the ECE region. A ban on internal combustion engines for light commercial vehicles (scenario E.4) would lead to 0.4 million new jobs in transport and to as many as 8.5 million new jobs if the impact on other sectors is also taken into account. The ECE region is likely, however, to see a contraction in certain sectors, since the net job creation under these scenarios masks considerable reallocation, with jobs moving away from the manufacture of motor vehicles and the petroleum industry towards the service sector.

In order to harness fully the employment opportunities arising from the electrification of private passenger and freight transport and the expansion of public transport, countries in the ECE region should adopt skills development policies to ensure that people are able to acquire the skills required to work in emerging sectors, such as the recycling of electric car batteries.

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An important finding is that most of the jobs arising from the electrification of private cars and light commercial vehicles in the ECE region will be located outside the region. This is because the ECE region has not yet developed sufficient capacity for the manufacture of electric vehicle components and batteries; in some cases, production has been outsourced to other regions. In order to increase employment opportunities in the region, the promotion of green and healthy transport needs to be accompanied by industrial policy designed to step up the production of batteries and electrical machinery and the expansion of rolling stock. Appropriate labour market policies are also necessary to ensure that the jobs created meet the criteria of decent work.

The transition to green and healthy transport will lead to the loss of jobs in certain sectors, which highlights the need for complementary policies, such as the provision of income support and activation support, to protect the workers and communities affected and enable them to find work in emerging sectors. Appendix II, which is based on the *Guidelines for a just transition towards environmentally sustainable economies and societies for all* (ILO, 2015a), provides more detailed recommendations on the policies that could be adopted to ensure that this transition creates jobs and promotes decent work.

It is important to stress that our analysis has focused on job creation, reallocation and destruction. The extent to which the job creation projected under the various scenarios contributes to decent work falls outside the report's scope. Nevertheless, decent work should be a key priority in the transition to green and healthy transport as part of broader efforts to promote social development and sustainability.<sup>22</sup>

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<sup>22</sup> Decent work, as defined by the ILO, rests on four pillars: employment, social protection, social dialogue and rights at work. It refers to work that is productive and provides: a fair income; security in the workplace and social protection for individuals and families; opportunities for personal development and social integration; freedom for people to express their concerns and to participate in the decisions that affect their lives; and equality of opportunity and treatment for all women and men.



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## Appendix I: Methodology

The projections presented in this report were obtained by modelling global, economy-wide scenarios of technology and demand change. We compared each of the public transport and electrification scenarios selected for the ECE region with a business-as-usual (baseline) scenario to estimate net employment creation across countries and sectors.

Following the methodology used in ILO (2018), the modelling of the scenarios relies on EXIOBASE, a multiregional input–output (MRIO) table that maps the interlinkages between final consumption, the flow of intermediate and final goods, and production inputs. EXIOBASE includes environmental and socio-economic parameters such as GHG emission levels and the number of people employed in each sector. A detailed description of EXIOBASE and its “labour accounts” can be found in Stadler et al. (2018). EXIOBASE includes information for 163 industries in 44 countries and five rest-of-the-world regions. The present study draws on the data from 2014 in EXIOBASE version 3.<sup>23</sup> These data are projected to 2030 by combining the International Monetary Fund’s GDP projections to 2022 with the International Energy Agency’s regional growth projections to 2030 (IEA, 2016; IMF, 2017). Partial equilibrium models are used to model changes in people’s transport choices resulting from policy interventions and to make appropriate changes to the final demands used in the MRIO table.

Changes in the transport sector affect economic activity and employment in other industries as well because the transport sector is linked (through forward and backward linkages) to other sectors in the economy. As an MRIO table tracks flows of goods and services within and between countries, EXIOBASE can be used to identify the broader effects of changes in the transport sector.

The projections obtained from the modelling of our scenarios are first-order direct and indirect effects. As is common in input–output studies that estimate employment effects (see e.g. Garrett-Peltier, 2017; ILO, 2018; Montt, Wiebe et al., 2018), these projections do not take into account the effects of substitution elasticities, utility and profit maximization, price equilibrium, etc. As explained in Montt, Wiebe et al. (2018), a methodology based on MRIO tables assumes that firms and sectors are able to absorb changes in demand immediately. Neither productivity increases in emerging industries nor the effects of completely new technologies or products that currently do not exist are taken into account. This methodology is also unable to consider labour-related adjustment effects: for example, owing to skills mismatch or other rigidities in the labour market, it may take longer for employment to adjust to changes in the demand for goods and services.

### A. Adapting EXIOBASE to represent the transport sector more accurately

Among the 163 sectors identified by EXIOBASE, transport is represented by “Transport via railways”, “Other land transport”, “Transport via pipelines”, “Sea and coastal water transport”, “Inland water transport” and “Air transport”. For the present study we look only at “Transport via railways and “Other land transport”. In order to represent the transport sector more accurately and capture the employment effects of the scenarios, we have disaggregated the two transport subsectors from EXIOBASE into: passenger road transport, passenger rail transport, freight road transport, and freight rail transport. This disaggregation was carried out using the output, gross operating surplus, wages, energy use (by type) and employment shares that correspond to the passenger and freight components of the two subsectors. The necessary data were obtained from the Structural Business Statistics maintained by Eurostat, the ECE’s transport statistics, publications issued by national statistical offices (e.g. the *Statistical Yearbook of Russia* and the United States Economic Census on Transportation and Warehousing), national railway companies’ financial statements,

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<sup>23</sup> The EXIOBASE data are available from: [www.exiobase.eu](http://www.exiobase.eu).



International Energy Agency statistics, and the *Transportation Energy Data Book* produced by Oak Ridge National Laboratory.

In some cases, original data were unavailable and had to be imputed: regression analysis was used to predict the values for the missing data on the basis of the observed transport data for a given country, its GDP per capita (in purchasing power parity terms), population and urbanization (as a percentage of the total population).

## B. Scenarios modelled for the study

In the sections below, we provide an outline of the methodological decisions that we took when modelling the various scenarios. The basic principles underlying each scenario are explained, as are the input–output changes required for the modelling.

### Scenario PT.1: Doubling investment in public transport

**Basic principles:** Between 2016 and 2030, investment in public transport infrastructure and in the rolling stock of passenger railway and bus services, including trams, underground railways and trolleybuses, is doubled, with the increase taking place progressively each year. The amount of rolling stock is used as a proxy for transport capacity. The scenario assumes that the additional investment in infrastructure is diverted from spending on motorways, and that the additional investment in rolling stock is paid for by sales taxes on fuel and new cars. Investment is doubled until a cap has been reached, which is set at the level of Switzerland for passenger rail services and that of Turkey for passenger bus services. Switzerland and Turkey had, in 2016, the highest observed number of passenger trains per capita and of passenger buses per capita, respectively. A minimum investment level is postulated to rule out any decrease in the rolling stock between 2016 and 2030. The increased use of public transport is accompanied by a reduction in the use and purchase of private cars and in fuel consumption.

#### Input–output changes:

- A doubling of the transport sector demand for rolling stock.
- Increase in household demand for transport services.
- Reduction in household demand for fuel and cars.
- Increase in household expenditure on other items as a result of savings.

These changes are applied only when modelling ECE countries, but the employment effects are analysed for both ECE countries and non-ECE countries.

**Magnitude of changes:** The annual investment in each country's public transport fleet is estimated from the year-to-year differences in the volume of rolling stock (ECE, 2018), adjusted for the depreciation rate of trains (3.75 per cent) and buses (8.5 per cent) (DETEC, 2011).<sup>24</sup> The formula for computing past investments is:

$$investment_{it}^v = stock_{it}^v - stock_{it-1}^v(1 - \delta^v)$$

(where  $v$  denotes the type of vehicle: train or bus  $i$  denotes the country and  $t$  denotes the year we use this to obtain an investment for the year 2016,  $investment_{i2016}^v$ . Investment is assumed to increase every year so that the level in 2030 is twice that of 2016, unless this would cause the resulting 2030 fleet of trains and buses (in per capita terms) to exceed, respectively, the 2016 values of Switzerland and Turkey, as discussed above. We also introduce lower bounds in order to rule out decreases in rolling stock in absolute terms, which is theoretically possible as some countries have inferred investment at such a low level, that (even

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<sup>24</sup> These numbers are averages of the stated maximum and minimum depreciation rates for each type of vehicle.

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after doubling their investment) the stock would decline. In this way we can calculate  $investment_{i,F}^v$ , where the subscript  $F$  stands for “future”.

The volume of rolling stock in 2030 is given by

$$y_{i2030} = stock_{i2016}(1 - \delta)^{14} + investment_{i,F}^v(1 - (1 - \delta)^{14})/\delta$$

The effect of increased rolling stock on the use of both public transport and private cars is modelled using estimates from the literature: Evans (2004), Duranton and Turner (2011), Lalive, Luechinger and Schmutzler (2018) and Beaudouin and Lin Lawell (2018).

The effect of increased public transport capacity on car ownership and use is also considerable, reflecting potential modal shifts that can advance green and healthy transport. Unfortunately, few, if any, existing studies present findings in a method that is applicable to the present report. We, therefore, estimate the relationship on the basis of national data using fixed-effects panel regression over the years 2000–2016.

The financing of the increased investment in public transport is assumed to come from the following sources: 80 per cent from fuel tax and 20 per cent from taxes on new car purchases. The reduction in demand for private cars as a result of higher purchasing costs is calculated using estimations by McCarthy (1996). Car use is also affected by the taxation of fuel. The resulting car use is calculated using estimates from Baranzini and Weber (2013), Havranek and Kokes (2015), Huntington, Barrios and Arora (2017), Odeck and Johansen (2016), Zeleke (2016).



## Scenario PT.2: Free public transport

**Basic principle:** Public transport becomes free for users, requiring greater government spending. As a result of the elimination of fares, the use of public transport increases, while fuel consumption and ownership of new cars are reduced. The scenario assumes that the additional government spending on public transport can be financed by taxes on fuel (80 per cent) and on sales of new cars (20 per cent).

### Input–output changes:

- Increase in government expenditure on transport.
- Reduction of household expenditure on transport.
- Reduction in household consumption of fuel.
- Reduction in household consumption of new vehicles.
- Increased household spending on non-transport uses.

These changes are applied only when modelling ECE countries, but the employment effects are analysed for both ECE countries and non-ECE countries.

**Magnitude of change:** It is envisaged that an additional 14 per cent of expenditure on public transport would be required as a result of increased demand after the elimination of fares (Cats, Susilo and Reimal, 2017). The growth in demand for public transport is partly explained by a modal shift away from cars, with demand for fuel falling by 16 per cent (ibid., 2017). The scenario assumes a reduction in retail fuel consumption by households based on fuel price elasticity, for which estimates have been provided in various studies (see e.g. Baranzini and Weber, 2013; Havranek and Kokes, 2015; Huntington, Barrios and Arora, 2017; Odeck and Johansen, 2016; Zeleke, 2016). The scenario also assumes a reduction in the purchase of new vehicles by households based on estimates by McCarthy (1996).

## Scenario E.3: Introduction of a voluntary or mandatory target of 50 per cent of all vehicles manufactured to be fully electric

**Basic principles:** Fifty per cent of the vehicles manufactured in the ECE region are to be fully electric by 2030. This implies a change in the technology of vehicle production and its input structure, along with a change in the inputs required in the use of such vehicles, with expenditure shifting from retail fuel to electricity. The scenario assumes that internal combustion engine vehicles and electric vehicles are perfect substitutes for each other.

### Input–output changes:

- The input structure of vehicle manufacture changes to account for 50 per cent of vehicles being manufactured using the inputs identified by UBS Research (2017).
- Change in the expenditure associated with vehicle use from retail fuel to electricity and reduction in the demand for repair services.
- Any savings accrued are spent equally on the remaining goods and services.

These changes are applied only when modelling ECE countries, but the employment effects are analysed for both ECE and non-ECE countries.

**Magnitude of changes:** The changes in intermediate input use correspond to those identified by UBS Research (2017). In all countries with an automotive industry, 50 per cent of the vehicles produced are assumed to be electric.

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#### Scenario E.4: Ban on internal combustion engines for light commercial vehicles

**Basic principles:** All light commercial vehicles in the ECE region are to be electric by 2030. The demand for commercial land transport as a whole does not change, nor does vehicle use.

**Input–output changes:**

- As in the E.3 scenario, this scenario involves a change in the technology used to produce the cars bought in the ECE region (intermediate input use based on UBS Research, 2017).
- Change in the expenditure associated with vehicle use from retail fuel to electricity and reduction in the demand for repair services.
- Any savings accrued are spent equally on other goods and services.

These changes are applied only when modelling ECE countries, but the employment effects are analysed for both ECE and non-ECE countries.

**Magnitude of changes:** The changes in intermediate demand coefficients correspond to those identified by UBS Research (2017).

## Appendix II: Policies to ensure that green and healthy transport is employment-friendly

The promotion of green and healthy transport is accompanied by changes to employment as a result of job creation, reallocation and destruction. Whether big or small, these changes will affect individual workers, businesses and, in certain cases, entire communities and regions that depend heavily on a specific industrial activity. Efforts to promote sustainability in other fields have been shown to have significant employment effects (e.g. through a transition to clean energy, to sustainable agriculture or to a circular economy, as highlighted in ILO, 2018).

Measures specific to the transport sector may help foster a transition to green and healthy transport, but complementary policies are necessary to ensure that workers have the skills required to make the transition happen and to provide protection to workers and communities negatively affected by the transition. The *Guidelines for a just transition towards environmentally sustainable economies and societies for all* (ILO, 2015a) provide a framework for identifying such policies.

As argued in more detail below, the consolidation of fundamental principles and rights at work, industrial policy, skills development, social protection and active labour market policies, and the promotion of social dialogue should complement any efforts to advance sustainability in the transport sector.

### A. Fundamental principles and rights at work

International labour standards provide a regulatory framework for employment in green and healthy transport. Developing suitable regulations is crucial because, as a result of the transition to new forms of transport, labour demand in certain industries will increase (particularly in the public transport and mining sectors), which can give rise to decent work challenges in countries where those industries are characterized by a high informality rate. National labour codes should be revised to ensure that fundamental principles and rights at work are upheld in these growing and emerging industries. Countries in the ECE region can further promote decent work principles by including labour rights provisions consistent with international labour standards in bilateral and multilateral trade and investment agreements with other countries that are supplying inputs for the transport sector (ILO, 2015b, 2016).

Appendix III provides a list of the international labour standards that are most relevant to the promotion of decent work in green and healthy transport.

### B. Industrial policies

#### *Trade and value chains*

Promoting green and healthy transport requires the adoption of policies in the transport sector that will inevitably influence demand for products and services in other sectors. Given that most of the world's batteries are currently produced outside the ECE region and that planned production in China exceeds that in the rest of the world (Ma et al., 2018), a significant proportion of the jobs associated with vehicle manufacturing supply chains may be reallocated to outside the ECE region. The scenarios considered for this report assume that the current trade structure does not change with time. This means that, unless capacity to produce the relevant inputs within the ECE region is increased, employment may move to other regions. A possibility in the ECE region would be to obtain copper not through the mining of copper ores but by adopting the principles of a circular economy and using copper recovery (ILO, 2018).

Governments should take into account the increased demand for inputs resulting from both the expansion of public transport and the electrification of vehicles by developing appropriate supply chains within the ECE region, which would help ensure that the promotion of green and healthy transport is also employment-

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friendly. The EU has begun to recognize the need for such industrial policy, by, for example, announcing funding for the construction of electric battery factories (Toplensky, 2018).

### *Sectoral considerations*

The introduction of greener transport will in some cases require agreements with private companies to build, lease and operate public transport systems and vehicle fleets. Changes in the ownership of urban passenger transport services may give rise to decent work-related challenges in the sector. Similarly, economic downturns can present difficulties for public authorities that are responsible for providing public transport services. A balance has to be struck between austerity measures and the need to maintain or improve the provision of those services (ILO, 2015c).

On the other hand, there are many opportunities to pave the way towards the modernization and greening of public transport, and to increase the number of passengers, including investments in renewal of the vehicle fleet, the introduction of priority bus lanes, the exploration of new sources of revenue, and the use of “mobility-as-a-service” approaches (ibid.).

## **C. Skills for the greening of the transport sector**

Advancing green and healthy transport has implications for employment throughout the economy and in the transport sector itself. The change in the production structure of, and the demand for, transport services affects employment not just in the transport sector but also in those sectors that provide the necessary inputs, such as manufacturing. All the sectors poised to experience an increase in demand require a skilled labour force. Anticipating these skills needs and creating the institutional linkages to develop the necessary skills in time are key policy objectives when it comes to achieving employment-friendly green and healthy transport in the ECE region (ILO, 2018; Strietska-Ilina et al., 2011).

Suitable training will have to be provided to workers responsible for the operation of public transport services and to workers engaged in the construction and maintenance of the underlying infrastructure. Similarly, it will be necessary to train technicians who can verify the compliance of public sector equipment with occupational health and safety regulations, and transport flow managers and modellers who are able to assist governments in minimizing the impact of transport and encouraging modal shifts. Bus and train drivers and public transport managers will have to be equipped with the skills to use new technologies such as satellite navigation, radio frequency identification and dual-mode systems, which are likely to be deployed as part of the further development of public transport (ibid.).

As noted by Strietska-Ilina et al. (2011), efforts to reduce vehicle fuel consumption will require technicians and engineers who are versed in the retrofitting and conversion of fuel systems. Problem-solving and technical diagnostic skills at a high level are called for among the mechanics who will be servicing and repairing electric vehicles. Similarly, an expansion in the number of electric vehicles will alter the skills profile of fuel station workers. Growth in the manufacture of electrical machinery and the construction sectors, as predicted by some of the scenarios studied in this report, will require an adequate policy response, which may include the retraining of workers in the motor vehicle industry and other industries that are set to experience job losses.

## **D. Social protection and active labour market policies**

Social protection policies are the first line of defence for workers faced with threats to their income security (ILO, 2017). In the context of efforts to advance green and healthy transport, such policies are necessary to protect workers who may lose out as a result of the reduced demand in specific sectors. Unemployment protection, social assistance and public employment programmes can help to support workers whose

livelihoods depend, directly or indirectly, on less environmentally friendly industries that will be edged out (ILO, 2018).

By providing income security for unemployed workers and their families, unemployment protection schemes help to prevent poverty, reduce vulnerability and facilitate the transition to new jobs, particularly if they are combined with skills development, job placement support and relocation grants. Unemployment protection is a fundamental measure in any social protection system, as recognized in the Social Protection Floors Recommendation, 2012 (No. 202) and the Social Security (Minimum Standards) Convention, 1952 (No. 102). Unemployment protection schemes are usually coupled with active labour market policies, such as job matching and counselling, entrepreneurship support and reskilling for workers transitioning to new jobs (Card, Kluve and Weber, 2010, 2018, ILO, 2014, 2017; Peyron Bista and Carter, 2017). Active labour market policies may also take the form of public employment programmes designed to advance sustainability at the same time by providing employment in infrastructure construction, environmental conservation or ecosystem restoration (ILO, 2018).

The potential of unemployment protection schemes to support the transition to greener economies is constrained by the fact that such schemes do not yet exist in many countries. On average, 57 per cent of unemployed workers in Eastern Europe receive unemployment benefits, 46 per cent in Northern, Southern and Western Europe, 28 per cent in North America, but only 12 per cent in Central and Western Asia.

The downsizing of environmentally damaging industries requires social protection schemes if it is to be socially and politically viable. Such schemes are necessary, in particular, to help workers in the motor vehicle manufacturing industry and related industries to transfer to new sectors. In the Philippines, for example, the closure of coal mines has been put on hold until suitable compensation measures have been introduced. This example shows how the lack of safeguards for workers who are at risk of losing out may hinder efforts to advance sustainability (ILO, 2018).

## **E. Social dialogue**

Social dialogue includes “all types of negotiation, consultation or information sharing among representatives of governments, employers and workers or between those of employers and workers on issues of common interest relating to economic and social policy” (ILO, 2013, p. 12). It can facilitate and accelerate the implementation of policies that enable a just transition, as has been the case in Barbados, France, South Africa and Spain, among other countries. More specifically, social dialogue can make it easier to identify the skills required for a successful transition to green and healthy transport, and to design effective skills development programmes. Social dialogue can also help promote the adoption of sustainable practices within a firm, through collective agreements that include “green provisions” or the appointment of an “environmental delegate” from among the workforce who is tasked with monitoring compliance with environmental regulations and identifying opportunities for enhancing sustainability (ILO, 2018; Montt, Fraga and Harsdorff, 2018; Montt, Karimova, et al., 2018).

Social dialogue can help to generate consensus on the specific measures that industries should take to promote employment-friendly green and healthy transport. This entails a commitment to sustainable development and requires an assessment of the social and economic implications of the relevant industrial transformations so that coherent policies can be designed to protect workers and advance decent work (ILO, 2012).

### **Box II.1. ILO publications providing guidance on social dialogue**

Relevant ILO publications providing guidance on social dialogue in public transport services include:

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*Practical guide for strengthening social dialogue in public service reform* (Geneva, ILO , 2005)

This publication offers practical guidance on strengthening social dialogue during periods of reform in the public services sector, such as following the adoption of decentralization and privatization policies.

*Manual on collective bargaining and dispute resolution in the public service* (Geneva, ILO, 2011)

This publication provides a compilation of examples of good practices in dispute prevention and resolution in public services. It sets out approaches and practices used by trade unions and public sector employers around the world to engage in social dialogue while ensuring minimal disruption to public services.

*Social dialogue in the railways sector* (Geneva, ILO, 2015)

This publication gives an overview of social dialogue in the railways sector (including urban railways) and provides practical examples and recommendations. It includes checklist sections that may be used in improving preparations for social dialogue.

An example of such a policy is the global framework agreement concluded in 2017 by the PSA Group (formerly PSA Peugeot Citroën) and the IndustriALL Global Union, which contains a specific commitment to sustainable development and places social dialogue at the heart of efforts towards such development. These efforts include measuring and reducing the corporation's environmental footprint, developing environmentally friendly products, promoting environmental protection among customers, suppliers and other stakeholders, and developing the workforce's skills to advance these goals. Similarly, in an agreement with the former International Metalworkers' Federation (now part of IndustriALL), signed in 2012, Ford committed to respecting the natural environment and to helping preserve it for future generations. The Renault Group commits, in its agreement with IndustriALL, to promoting sustainable transport by improving the carbon and environmental footprint of its vehicles and their life cycle, particularly through its range of electric vehicles. Similar provisions are included in the international framework agreements concluded with IndustriAll by, respectively, Bosch, Saab, and ZF Friedrichshafen.<sup>25</sup>

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<sup>25</sup> On the other hand, the agreements concluded by IndustriALL with Daimler, the Man Group, Siemens and Volkswagen do not include such environmental provisions. All these and other agreements may be consulted at: [www.industrialunion.org/issues/confronting-global-capital/global-framework-agreements](http://www.industrialunion.org/issues/confronting-global-capital/global-framework-agreements). Environmental clauses are also missing in the agreements concluded by major transport infrastructure constructors and the Building and Wood Workers' International (BWI). Still, the agreements between BWI and Lafarge, Salini Impregilo and Veidekke do include a reference to improving the respective companies' environmental performance. These and other agreements are available at <http://connect.bwint.org/default.asp?Issue=Multinationals&Language=EN>.

## Appendix III: International labour standards relevant to employment in green and healthy transport

In addition to the eight Conventions on fundamental principles and rights at work and the four governance Conventions,<sup>26</sup> the following international labour standards are specifically relevant to employment in green and healthy transport:

### Technical Conventions:

- Social Security (Minimum Standards) Convention, 1952 (No. 102)
- Social Policy (Basic Aims and Standards) Convention, 1962 (No. 117)
- Paid Educational Leave Convention, 1974 (No. 140)
- Human Resources Development Convention, 1975 (No. 142)
- Working Environment (Air Pollution, Noise and Vibration) Convention, 1977 (No. 148)
- Labour Administration Convention, 1978 (No. 150)
- Labour Relations (Public Service) Convention, 1978 (No. 151)
- Hours of Work and Rest Periods (Road Transport) Convention, 1979 (No. 153)
- Collective Bargaining Convention, 1981 (No. 154)
- Occupational Safety and Health Convention, 1981 (No. 155)
- Occupational Health Services Convention, 1985 (No. 161)
- Chemicals Convention, 1990 (No. 170)
- Prevention of Major Industrial Accidents Convention, 1993 (No. 174)
- Promotional Framework for Occupational Safety and Health Convention, 2006 (No. 187)

### Recommendations, resolutions and conclusions:

- Labour Inspection (Mining and Transport) Recommendation, 1947 (No. 82)
- Hours of Work and Rest Periods (Road Transport) Recommendation, 1979 (No. 161)
- Human Resources Development Recommendation, 2004 (No. 195)
- Social Protection Floors Recommendation, 2012 (No. 202)
- *Resolution concerning the promotion of sustainable enterprises*, adopted by the International Labour Conference during its 96th Session in June 2007
- *Resolution concerning promotion of rural employment for poverty reduction*, adopted by the International Labour Conference during its 97th Session in June 2008
- *Conclusions on safety and health in the road transport sector*, adopted by the ILO Tripartite Sectoral Meeting on Safety and Health in the Road Transport Sector in October 2015
- *Resolution concerning best practices in road transport safety*, adopted by the ILO Tripartite Sectoral Meeting on Safety and Health in the Road Transport Sector in October 2015

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<sup>26</sup> See: <https://www.ilo.org/dyn/normlex/en/f?p=1000:12000::NO::>

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## **Appendix IV: Steering Group for the study *Jobs in green and healthy transport: Making the shift***

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International  
Labour  
Organization

# Jobs in green and healthy transport

## Making the green shift

This study on jobs in green and healthy transport has been carried out in the context of the ongoing Partnership on Jobs in Green and Healthy Transport within the Transport, Health and Environment Pan-European Programme (THE PEP).

The study continues the work of THE PEP on evaluating the job creation potential of green and healthy transport by reviewing the economy-wide employment implications of an accelerated shift towards greener land transport.

The study shows how changes towards green and healthy transport alter the structure of sectors and jobs across ECE member States and also in other parts of the world, given that greening the transport sector activates different national, regional and global value chains and employment in different industries and areas of the world.

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